Route 20 Transportation Planning Study

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TABLE OF CONTENTS

LIST OF FIGURES ix

LIST OF TABLES xi

1 BACKGROUND 1

1.1 INTRODUCTION 1

1.2 STUDY AREA 2
1.2.1 Transportation 2
1.2.2 Land Use 2

1.3 STUDY PURPOSE 5
1.3.1 Study Goal 5
1.3.2 Study Tasks 5

1.4 PUBLIC PARTICIPATION AND MUNICIPAL AND AGENCY INVOLVEMENT 6
1.4.1 Technical Advisory Committee 6
1.4.2 Public Meetings 7

2 IDENTIFIED PROBLEMS 9

2.1 OVERVIEW 9

2.2 ARTERIAL AND INTERSECTION-RELATED PROBLEMS 9
2.2.1 Vehicular Traffic Delays at Critical Intersections Along Route 20 in Boston 10
2.2.2 Vehicular Traffic Delays at Critical Intersections Controlled by the MDC in the Route 20 Corridor 16
2.2.3 Vehicular Traffic Delays at Critical Intersections Along Route 20 in Watertown 19
2.2.4 Vehicular Traffic Delays at Critical Intersections Along Route 20 in Waltham 24
2.2.5 Inconsistent Lane Assignments 28
2.2.6 Intersection Safety Problems 28
2.2.7 On-Street Parking Problems 38

2.3 TRANSIT-RELATED PROBLEMS 44
2.3.1 Bus Transit Problems 45
2.3.2 Green Line B Branch Light Rail Transit (LRT) 50
2.3.3 Park-and-Ride Lots 58

2.4 PEDESTRIAN CROSSING AND ACCESS ISSUES 61
2.4.1 Pedestrian Crossing at Kenmore Square in Boston 61
2.4.2 Pedestrian Crossing in the Boston University Area Along Commonwealth Avenue 62
2.4.3 Pedestrian Crossing at the North Beacon Street and Greenough Boulevard Intersection in Watertown 62

2.5 BICYCLE TRAFFIC AND SAFETY ISSUES 68
2.5.1 Bicycle Storage Facilities 68
2.5.2 Improved Signal Timings 68
2.5.3 Integration of Bike Paths and Lanes in Waltham and Watertown 69
2.5.4 Allocation of Road Space for Parking and Bike Use 69

3 PROPOSED STRATEGIES TO ADDRESS PROBLEMS IDENTIFIED IN WALTHAM 71

3.1 STRATEGIES TO ADDRESS ARTERIAL AND INTERSECTION-RELATED PROBLEMS 71
3.1.1 Strategies to Reduce Intersection Traffic Delays 71
3.1.2 Strategies to Resolve Inconsistent Lane Assignment in Waltham 77
3.1.3 Strategies to Improve Traffic Safety in Waltham 83

3.2 STRATEGIES TO ADDRESS TRANSIT-RELATED PROBLEMS 93
3.2.1 Reducing Traffic Signal Delay Facing Route 70 Bus Service 93
3.2.2 Park-and-Ride at Waltham Central Square Station 94

3.3 STRATEGIES TO IMPROVE BICYCLE TRANSPORTATION 95
3.3.1 Install Bike Storage Facilities 95
3.3.2 Increase Signal Clearance Time 95
3.3.3 Install Bike Signs 95
3.3.4 Integration of Bicycle Transportation 95

4 PROPOSED STRATEGIES TO ADDRESS PROBLEMS IDENTIFIED IN WATERTOWN 101

4.1 STRATEGIES TO ADDRESS ARTERIAL AND INTERSECTION-RELATED PROBLEMS 101
4.1.1 Addressing Traffic Delays at Watertown Square 101
4.1.2 Main Street and Waverly Avenue/Myrtle Street in Watertown 104

4.1.3 Main Street and Lexington Street 106
4.1.4 Strategies to Improve Traffic Flow on North Beacon Street at the Town Line of Watertown and Boston (Brighton) 109

4.2 STRATEGIES TO ADDRESS TRANSIT-RELATED PROBLEMS 114
4.2.1 Passenger Transfers Between the Watertown Square and Watertown Yard Terminals 114
4.2.2 Improving Schedule Adherence for Bus Routes 57 and 70 114
4.2.3 Passenger Crowding on Bus Routes 57 and 70 115

4.3 PEDESTRIAN CROSSING ISSUES 117
4.3.1 Strategies to Improve Pedestrian Crossing at North Beacon Street and Greenough Boulevard 117

4.4 STRATEGIES TO IMPROVE BICYCLE TRANSPORTATION 119
4.4.1 Bicycle Storage Facilities 119
4.4.2 Install Bike Signs 119
4.4.3 Integration of Bicycle Transportation 119

5 PROPOSED STRATEGIES TO ADDRESS PROBLEMS IDENTIFIED IN BOSTON 121

5.1 NEW PROJECTS AND DEVELOPMENTS 121

5.2 STRATEGIES TO ADDRESS ARTERIAL AND INTERSECTION-RELATED PROBLEMS 123
5.2.1 Intersection Traffic Delays 123
5.2.2 Strategies to Address Illegal and Double-Parking 132

5.3 STRATEGIES TO ADDRESS TRANSIT-RELATED PROBLEMS 135
5.3.1 Bus Transit Strategies 135
5.3.2 Green Line B Branch Strategies 139

5.4 PEDESTRIAN/BICYCLE ISSUES 150
5.4.1 Addressing the Kenmore Square Pedestrian Issues 150
5.4.2 Addressing Pedestrian Crossing Problems Along Commonwealth Avenue in the BU Area 152

6 SUMMARY OF RECOMMENDATIONS, WITH IMPLEMENTATION PLAN 153

6.1 RECOMMENDED IMPROVEMENTS IN WALTHAM 153

6.2 RECOMMENDED IMPROVEMENTS IN WATERTOWN 155

6.3 RECOMMENDED IMPROVEMENTS IN BOSTON 156

6.4 IMPLEMENTATION 158
6.4.1 Implementation Plan 158
6.4.2 Implementation Process 162

APPENDICES
(separately bound)

APPENDIX A – Public Participation

1. Meeting Minutes: June 24, 1997
2. Meeting Minutes: December 11, 1997
3. Comments Received via Mail

APPENDIX B – Traffic Delays: Existing Conditions

1. Intersection Delays and Levels of Service for Critical Intersections in Boston
2. Intersection Delays and Levels of Service for Critical Intersections Controlled by the MDC
3. Intersection Delays and Levels of Service for Critical Intersections in Watertown
4. Intersection Delays and Levels of Service for Critical Intersections in Waltham

APPENDIX C – Transit Performance: Existing Conditions

Table C-1 Cumulative Delay for Buses Running on Route 20: Existing Conditions
Table C-2 Green Line B Branch: Trolley Priority Equipment Status for the Inbound Direction
Table C-3 Green Line B Branch: Trolley Priority Equipment Status for the Outbound Direction
Table C-4 Green Line B Branch: Station Dwell Time for the AM Peak Hour
Table C-5 Green Line B Branch: Station Dwell Time for the PM Peak Hour
Table C-6 Green Line B Branch: Walk Access Time
Table C-7 Green Line B Branch: Access Modes
Table C-8 Green Line B Branch: Wait Time at Boarding Stations
Table C-9 Green Line B Branch: Person Hours of Delay, Existing Conditions

APPENDIX D – Traffic Delays: With Improvements

1. Intersection Delays and Levels of Service for Critical Intersections in Boston
2. Intersection Delays and Levels of Service for Critical Intersections Controlled by the MDC
3. Intersection Delays and Levels of Service for Critical Intersections in Watertown
4. Intersection Delays and Levels of Service for Critical Intersections in Waltham

APPENDIX E – Transit Performance: With Improvements

Figure E-1 Existing Green Line B Stations in the Route 20 Corridor

Figure E-2 Proposed Lane Configurations Resulting from the Commonwealth Avenue Road Reconstruction Project (Segment A)

Table E-1 Cumulative Delay for Buses Running on Route 20: With Improvements

Table E-2 Green Line B Branch Person Hours of Delay: Trolley Priority with Existing Lane Configuration and Stations

Table E-3 Green Line B Branch Person Hours of Delay: Trolley Priority with Proposed Lane Configuration and Existing Stations

Table E-4 Green Line B Branch Person Hours of Delay: Trolley Priority with Existing Lane Configuration and Stations at the Far Side of Intersection

Table E-5 Green Line B Branch Person Hours of Delay: Trolley Priority with Proposed Lane Configuration and Stations at the Far Side of Intersection

Simulating the Green Line B Branch Trolley Priority System: TRAF-NETSIM Model Deficiencies

LIST OF FIGURES

1-1 Highway Administrative Control 3
2-1 Intersections with Excessive Traffic Delays in Boston 13
2-2 Peak Hour Turning Movement Counts at Critical Intersections in Boston 14
2-3 Signalized Intersections Controlled by the MDC in the Route 20 Corridor 17
2-4 Peak Hour Turning Movement Counts at Critical Intersections Along Route 20 Controlled by the MDC 18
2-5 Intersections with Excessive Traffic Delays in Watertown 21
2-6 Peak Hour Turning Movement Counts at Critical Intersections in Watertown 22
2-7 Intersections with Excessive Traffic Delays in Waltham 25
2-8 Peak Hour Turning Movement Counts for Critical Intersections Along Route 20 in Waltham 26
2-9 Inconsistent Lane Assignment at the Intersection of Main Street and Elm Street/Church Street in Waltham 29
2-10 Signal Indications Shown to Motorists at the Eastbound Approach of Main Street and Linden Street Intersection in Waltham 31
2-11 Signal Indications at the Westbound Approach of Weston Street and Cedarwood Avenue/Tavern Road Intersection in Waltham 33
2-12 Banks Square Intersection in Waltham 35
2-13 Signage at the Intersection of Weston Street, Livingstone Lane, Sibley Road, and Route 20/Route 128 Rotary Interchange in Waltham 37
2-14 Locations with Illegal and Double-Parking Along Commonwealth Avenue in Boston 39
2-15 Illegal Parking at Union Square in Brighton 43
2-16 Bus Access Problem at the Kenmore Square Station in Boston 46
2-17 Bus Navigation Problem at Union Square in Boston 47
2-18 Bus Transfers Problem Between Watertown Square and Watertown Yard Terminals in Watertown 51
2-19 Parking Access and Availability at Central Square in Waltham 59
2-20 Pedestrian Crosswalks at Kenmore Square in Boston 63
2-21 Pedestrian Crossing Volumes at Kenmore Square in Boston 65
2-22 Integration of Bike Transportation in Watertown and Waltham 70
3-1 Retimed and Coordinated Traffic Signals in Waltham 72

3-2 Proposed Improvements at the Intersection of Main Street and Lyman/Heard Streets in Waltham 79
3-3 Proposed Improvements to Address Inconsistent Lane Assignments at Main Street and Elm Street in Waltham..... 81
3-4 Proposed Improvements to Address the Eastbound Signal Indication Problem at Main Street and Linden Street in Waltham..... 85
3-5 Proposed Improvements to Address Signal Indication Problem at the Westbound Approach of Weston Street at the Intersection with Cedarwood Avenue/Tavern Road in Waltham 89
3-6 Proposed Strategy for Improving Safety at Banks Square Intersection in Waltham..... 91
3-7 Signage at Weston Street, Livingstone Lane, Sibley Road, and Route 20/Route 128 Rotary Interchange in Waltham 92
3-8 Parking Access and Availability at Central Square in Waltham..... 97
3-9 Candidate Streets For Bike Lane Integration in Waltham and Watertown 99
4-1 Traffic Signals in Watertown Proposed for Retiming..... 102
4-2 Levels of Service Projected to Result from Signal Retiming at Watertown Square Intersection 105
4-3 Proposed Improvements at the Intersection of Main Street and Waverly Avenue/ Myrtle Street in Watertown with Estimated Levels of Service 107
4-4 Proposed Improvements at the Intersection of Main Street and Lexington Street in Watertown with Estimated Levels of Service 108
4-5 Proposed Improvements at the MDC Traffic Signals at the Town Line of Watertown and Boston (Brighton) with Estimated Levels of Service 110
4-6 AM Peak Phasing Patterns and Sequences for Signal Synchronization at the MDC Traffic Signals (Watertown/Boston) 112
4-7 PM Peak Phasing Patterns and Sequences for Signal Synchronization at the MDC Traffic Signals (Watertown/Boston) 113
4-8 Proposed Improvements for Pedestrian Crossing at the Intersection of North Beacon Street and Greenough Boulevard in Watertown 118
5-1 Proposed Traffic Phasing Pattern for Kenmore Square in Boston..... 126
5-2 Proposed Improvements at the Intersection of Brighton Avenue and Harvard Street in Boston with Estimated Levels of Service 130
5-3 Proposed Improvements at the Intersection of North Beacon Street and Market Street in Boston with Estimated Levels of Service..... 133
5-4 Green Line B Branch Trolley Priority System, Relocation of Near-Side Stops..... 149
5-5 Pedestrian Recommendations at Kenmore Square in Boston 151
6-1 Summary of Proposed Improvements in Waltham 165
6-2 Summary of Proposed Improvements in Watertown 167
6-3 Summary of Proposed Improvements in Boston..... 169

LIST OF TABLES

2-1 Level of Service Criteria 11

2-2 Intersection Control Strategies and Operations at Critical Intersections Along Route 20 in Boston 12

2-3 Approach Delays and Levels of Service for Critical Intersections in Boston 15

2-4 Approach Delays and Levels of Service for Critical Intersections in the MDC Jurisdictional Area in Brighton 19

2-5 Approach Delays and Levels of Service for Critical Intersections in Watertown 23

2-6 Approach Delays and Levels of Service for Critical Intersections in Waltham 27

2-7 Double-Parking and Illegal Parking Statistics Along Commonwealth Avenue in the Boston University Area: Westbound 41

2-8 Double-Parking and Illegal Parking Statistics Along Commonwealth Avenue in the Boston University Area: Eastbound 42

2-9 Bus Passenger Transfers at the Watertown Square and Watertown Yard Terminals 53

2-10 Cumulative Passenger Hours of Delay for Existing Conditions 54

2-11 Passenger Survey Responses Regarding Customer Service on the Green Line B Branch (Light Rail Transit) 55

2-12 Green Line B Branch Passengers per Seat for the Peak Period 56

2-13 Passenger Crowding on the Green Line B Branch (Light Rail Transit) 57

2-14 Peak Period Capacity and Reserve Seating at Waltham Commuter Rail Station 60

2-15 Pedestrian and Driver Behavior Along Commonwealth Avenue in the BU Area 66

2-16 Pedestrian Crossing Volume by Intersection Along Commonwealth Avenue in the BU Area 67

3-1 Mode of Operation and System Grouping for Signalized Intersections Along Route 20 in Waltham 74

3-2 Approach Delays and Levels of Service Estimated to Result from Retiming and Coordinating Traffic Signals Along Route 20 in Waltham (Subsystem 1) 75

3-3 Approach Delays and Levels of Service Estimated to Result from Retiming and Coordinating Traffic Signals Along Route 20 in Waltham (Subsystem 2) 76

3-4 Traffic Signal Warrant Analysis for Main Street and Lyman Street/Heard Street 78

3-5 Proposed Strategies to Prevent Entrapment in Turn-Only Bays in Waltham 83

3-6 Cumulative Bus Passenger Hours of Delay, Route 70 Bus Service 94
4-1 Approach Delays and Levels of Service Estimated to Result from Retiming Traffic Signals Along Route 20 (Main Street) in Watertown 104
4-2 Estimated Approach Delays and Levels of Service for MDC Intersections with Proposed Improvements 111
4-3 Cumulative Bus Passenger Hours of Delay for Route 57 and 70 Bus Services 116
5-1 Approach Delays and Levels of Service Estimated to Result from the Proposed Improvements at the Charlesgate East and Kenmore Square Intersections 125
5-2 Approach Delays and Levels of Service Estimated to Result from Proposed Signal Coordination Along Commonwealth Avenue (from Blandford and Sherborn Streets to Babcock Street) 129
5-3 Route 20 Cumulative Bus Passenger Hours of Delay 138
5-4 Passenger Crowding Characteristics for Bus Routes 57 and 66 (Calculated Using the Present 40-Seat Buses) 140
5-5 Headway Recommendations for Bus Routes 57 and 66 140
5-6 Total Reduction in Signal Delay for Trolleys Estimated to Result from Trolley Priority System 146
5-7 Peak Hour Person Hours of Delay Savings Estimated to Result from Trolley Priority System 147
6-1 Route 20 Transportation Planning Study: Proposed Projects, Summary and Implementation Plan 159

1. BACKGROUND

1.1 INTRODUCTION

The Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 mandated the development and implementation of a Congestion Management System (CMS) in each metropolitan area with a population of 200,000 or more. This bill established the CMS to identify and implement strategies to provide efficient use of existing transportation facilities and improve air quality for areas classified as air quality non-attainment (areas with air quality below the federal standards). CMS requirements must be considered in the development of the Transportation Improvement Program (TIP).

As part of the Boston region's CMS efforts, a report on mobility in the region is prepared annually. This report describes the existing highway and transit conditions, identifies problem areas, and provides a plan for action. Based on travel times, crowded transit services, and parking problems, the CMS report for 1996 identified Route 20 (from the Boston CBD to Route 128 in Waltham) as a congested corridor. [1]

Average travel times on many segments of Route 20 are undesirably high during the peak periods due to intersection delays. Public transportation service needs improvements to reduce crowding, make it more reliable, and facilitate transfers. There are several locations along Route 20 with pedestrian safety problems. Bicycle transportation is not well integrated in the corridor to encourage people to bike.

Because of the complex land uses and variety of transportation modes in this corridor, the CMS report recommended a multimodal study to improve mobility in the Route 20 corridor. This study was sponsored by Massachusetts Highway Department's (MassHighway) Bureau of Transportation Planning and Development. The Central Transportation Planning Staff (CTPS) of the Boston Metropolitan Organization (MPO) conducted this study with a high level of community, municipal, and agency participation.

This report is organized into six chapters. This first chapter gives the background of the study. It describes the study area, the purpose of this study, the process used to conduct it, and the process used to solicit inputs from the general public and ensure the participation of

[1] *Mobility in the Boston Region, Existing Conditions and a Plan for Action: The Congestion Management System Annual Report for 1996*, Central Transportation Planning Staff for the Boston Metropolitan Planning Organization, November 1996.

appropriate state and city officials and agencies. The second chapter documents the existing transportation conditions. Detailed descriptions of the transportation problems identified along Route 20 are provided in this chapter. The third, fourth, and fifth chapters present proposed strategies and improvements to address the problems identified in, respectively, Waltham, Watertown, and Boston. The sixth and final chapter is devoted to issues pertinent to the successful implementation of the study recommendations. A series of Appendices (published separately) will contain meeting minutes and most of the data and information collected as part of this study.

1.2 STUDY AREA

1.2.1 Transportation

This study examines Route 20 between Arlington Street in Boston and Route 128 in Waltham (10.40 miles). A substantial portion of the route is under the administrative control of the cities and towns along the corridor (see Figure 1-1). However, two segments, one extending between Waverly Avenue and Warren Street in Watertown (about 1.20 miles) and the other between Eddy Street and Route 128 in Waltham (about 1.12 miles) are under MassHighway's administrative control. The Metropolitan District Commission (MDC) administers the North Beacon Street segment of Route 20 from Charles River Road to the point where North Beacon Street diverges from Birmingham Parkway and passes under the Massachusetts Turnpike.

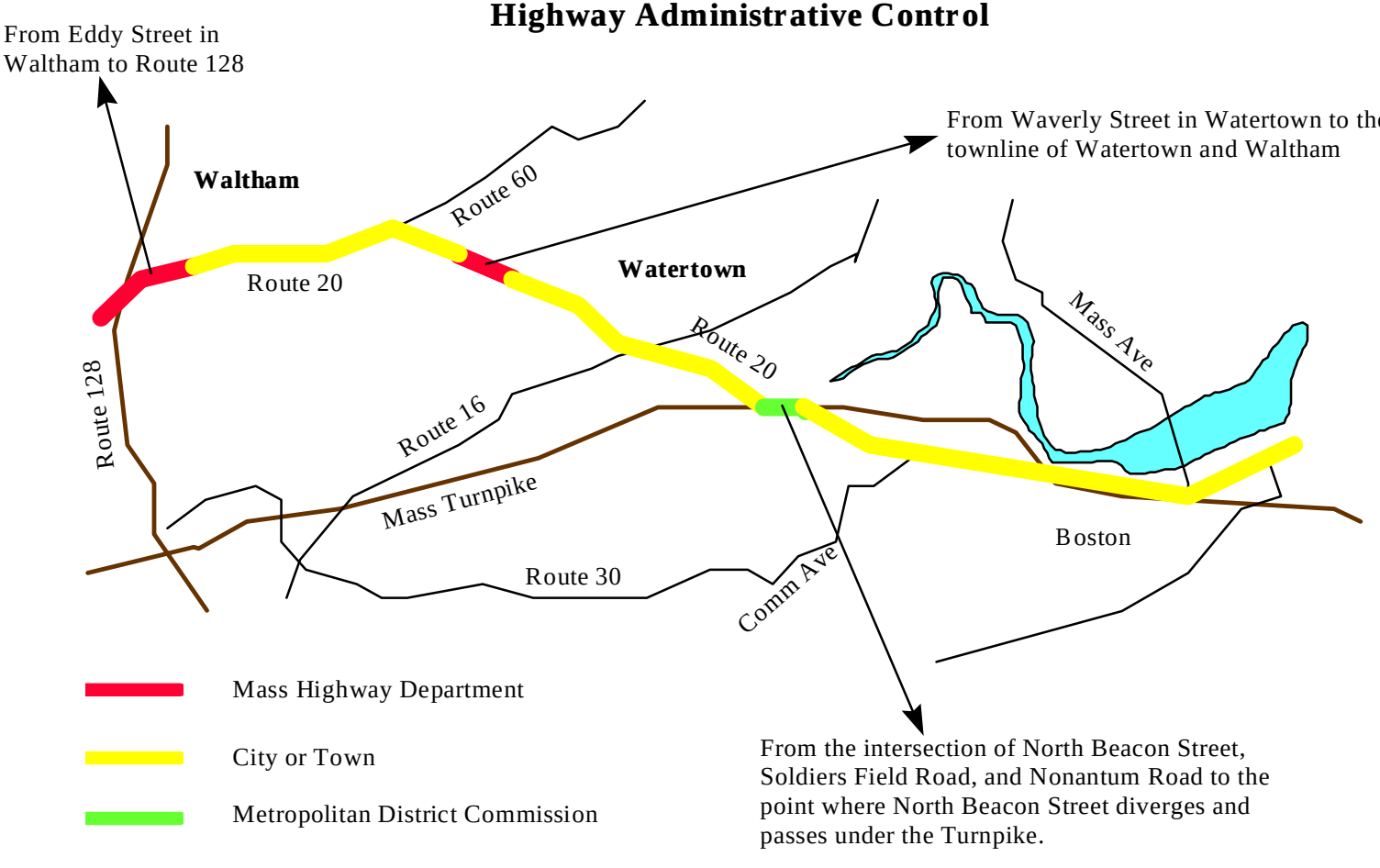
Route 20 is an urban principal arterial with average annual daily traffic (AADT) of more than 13,600 vehicles on most segments. The number of lanes varies along its entire length. In certain segments it is a four-lane divided arterial, while in other segments it is a two-lane or four-lane undivided arterial. Route 20 has different names in the different cities and towns along the study corridor. In Boston, it is called Commonwealth Avenue; in Allston, Brighton Avenue; in Brighton and Watertown, North Beacon Street; and in Waltham, Main Street and Weston Street.

Besides the highway system, there are public transportation systems serving this corridor. The Massachusetts Bay Transportation Authority (MBTA) has several bus routes serving all three communities (Boston, Watertown, and Waltham). The Green Line B Branch light rail transit, operated by the MBTA, also serves this corridor. The MBTA's Fitchburg commuter rail line has a station and a park-and- ride lot at Waltham Central Square.

1.2.2 Land Use

The Route 20 corridor has various land uses, including residential, commercial, industrial, educational, and recreational. From Boston through Brighton, Route 20 serves primarily institutional and commercial activities mixed with some residential neighborhoods. The major institutional and commercial areas are Kenmore Square and Boston University (BU) in Boston and Brighton Avenue (Union Square) in Allston and Brighton.

FIGURE 1-1
Highway Administrative Control



At the town line of Boston (Brighton) and Watertown, Route 20 (North Beacon Street) runs through a recreational area along the Charles River. This segment, from where North Beacon Street joins Birmingham Parkway to where it intersects with Charles River Road in Watertown, is controlled by the MDC. In both Waltham and Watertown, Route 20 runs through commercial areas at the city centers and through residential neighborhoods in the remaining areas.

1.3 STUDY PURPOSE

1.3.1 Study Goal

The primary goal of this planning study is to reduce congestion and improve mobility along Route 20. Emphasis is placed on improvements that will increase the safety, efficiency, and person throughput in the corridor. To this end, this study considers all travel modes: highway, transit, bicycle, and walking.

For successful implementation of the study recommendations, considering the jurisdictional and administrative structures, a plan has been developed that will allow the proposed improvements to be carried out independently or in phases. Such an implementation plan will not only provide flexible choices for the decision makers but also simplify other issues such as funding. For example, signal timing improvements can be packaged separately from transit service improvements.

1.3.2 Study Tasks

To achieve the study's goal the following tasks were performed:

1. Initiate a Technical Advisory Committee (TAC) to provide expert advice and guidance.

   Three municipalities and four agencies were contacted for information on new developments and perceived plans for the corridor. Representatives from municipalities of Boston, Watertown, and Waltham and from the Executive Office of Transportation and Construction (EOTC), MassHighway, the MDC, the MBTA, and the Metropolitan Area Planning Council (MAPC) were designated to serve on the TAC. The committee provided oversight, resolved issues, and brought all parties to general agreement.

2. Identify and evaluate the existing transportation problems.

   Through field reconnaissance studies, meetings with the agencies and municipalities, analyses of field data, and input from the general public, the existing transportation conditions were evaluated and the problems identified. Where possible, appropriate traffic engineering analyses were performed to quantify the extent and magnitude of

the problem. The identified problems were reviewed by the TAC and presented to the general public for comments.

3. Find appropriate strategies to address the existing problems.

   The agencies and municipalities were involved in developing strategies, alternatives, and final solutions to address the identified problems. Consensus among all parties on which strategies to use is important to the successful implementation of our recommendations. The TAC and public meetings were the main channels used to achieve consensus.

4. Develop an implementation plan for the recommendations.

   Because the study corridor spans three municipalities and has several transportation facilities controlled and operated by different agencies, and because many of the problems are site-specific, an implementation plan is needed to successfully carry out the recommendations. The implementation plan must respect the jurisdictional and administrative structures that are in place.

1.4 PUBLIC PARTICIPATION AND MUNICIPAL AND AGENCY INVOLVEMENT

A high level of participation by the public, municipalities, and agencies was a primary focus of this study. A cooperative approach involving all parties was adopted.

1.4.1 Technical Advisory Committee

A Technical Advisory Committee (TAC) comprising representatives of the agencies and municipalities was formed to provide a common ground for guidance, expert advice, and consensus. The TAC role included helping to plan public meetings. It met on as-needed basis to review materials. State senators, representatives, and city councilors with districts along the study corridor were invited to the committee meetings and received minutes of the meetings. This was done to keep them informed and to obtain their input. The following individuals were appointed to the technical advisory committee:

MassHighway-Traffic	Hari Vohra
MassHighway-Planning	Mark Berger
MassHighway-District Four	Todd Delvecchio and Joseph Onorato
MAPC	Timothy Wagner
MBTA	James C. Nolan
MDC	Julia O'Brien
Waltham	Lisa Weber
Watertown	Gerald Mee Jr.
Boston	Thomas Kadzis

1.4.2 Public Meetings

As part of the public involvement process, two public meetings were held. A joint public meeting was held for the city of Waltham and the town of Watertown on Tuesday, June 24, 1997, at 7:30 p.m., in the auditorium at Government Center, 119 School Street, Waltham. The purpose of this meeting was to present to the community the traffic operations and safety problems we had identified and to get feedback from citizens on the problems and how to solve them.

The second public meeting was held for the same two communities on Thursday, December 11, 1997, at 7:00 p.m., in the Lower Hearing Room at Watertown Town Hall, 149 Main Street, Watertown. The purpose of the second meeting was to present our recommendations to the general public for comments.

Several media strategies were used to publicize the public meetings. Pre-meeting materials, including the announcements and the agenda, were broadcast on the community access TV channels in Waltham and Watertown and on the local radio stations. The meeting announcements were published in the local newspapers *(Watertown Sun, Watertown Tab and Press,* and *Waltham News Tribune)* and posted on the Boston MPO Web site. Fliers making the announcement were also sent to the local public libraries in Waltham and Watertown. State and city officials were informed of the public meetings via mail.

The following agencies and associations in Watertown were sent notices of the public meetings: Watertown Town Council, Watertown Planning Board, Watertown Conservation Commission, Watertown Department of Public Works, Watertown Chamber of Commerce, Bicycle Committee, Concerned Citizens Group, East Watertown Betterment Association, Watertown Citizens for Environmental Safety, and Trees for Watertown. In Waltham, the agencies and associations that were sent notices included the Waltham City Council, Cedarwood Association, Waltham Council of Neighborhood Associations, Ravenswood Association, Main Street Business Association, Waltham Traffic Commission, and Waltham West Suburban Chamber of Commerce.

The public meetings provided useful input for the planning study. They confirmed the problems we had already identified, provided us with a sense of what improvements the public wants along Route 20, and elicited public approval of our recommendations. In conclusion, municipal and agency involvement and public meetings provided a complete picture of the transportation improvements needed along Route 20. Minutes of the meetings are included in Appendix A of this report.

No public meeting was held in Boston. The Commonwealth Avenue and Brighton Avenue Reconstruction Projects went through extensive public and community participation process. Inputs from the community regarding these projects were considered in this study.

2. IDENTIFIED PROBLEMS

2.1 OVERVIEW

In this chapter, the transportation problems in the Route 20 corridor are described, along with the quantitative and qualitative analyses performed to assess the transportation system and identify the problems.

Travel time studies were conducted to identify those segments of Route 20 which experience vehicular traffic delays. Intersection turning movement counts and signal timing information were collected and analyzed to determine those intersections with excessive traffic delays. Field reconnaissance studies were also conducted to identify other problems along Route 20 such as inconsistent lane assignments, on-street double parking, and pedestrian safety problems.

Bus passenger loading and performance data collected by CTPS were analyzed for the bus lines serving the corridor to identify those routes which have problems in the areas of crowding, timed transfer, or scheduling. Passenger survey data for the B Branch of the Green Line were used to determine passengers' perception of Green Line service quality; performance data collected by CTPS for the MBTA were also used to determine passenger crowding levels and station dwell times. Park-and-ride usage data collected for CMS studies were examined for the Waltham park-and-ride facility.

These processes and the public participation process were used to evaluate the existing transportation conditions, problems, and needs along Route 20. The identified problems are described in detail in the subsequent sections:

- Arterial and Intersection-Related Problems
- Transit-Related Problems
- Pedestrian Crossing and Access Issues
- Bicycle Traffic and Safety Issues

2.2 ARTERIAL AND INTERSECTION-RELATED PROBLEMS

The Highway Capacity Software (HCS) was used to analyze the levels of service at both signalized and unsignalized intersections. The levels of service established by the 1994 Highway

Capacity Manual (HCM) for both kinds of intersection are summarized in Table 2-1. Traffic delays resulting in level of service (LOS) A through LOS D are considered acceptable, while LOS E or F is considered unacceptable.

Peak hour turning movement counts were conducted and data were collected on intersection geometry, signal timings and plans, and operational features for use in performing detailed intersection capacity analyses.

2.2.1 Vehicular Traffic Delays at Critical Intersections Along Route 20 in Boston

For the purposes of our study, Route 20 in the Boston area was divided into four segments:

- Segment 1: Commonwealth Avenue from Arlington Street to Kenmore Square (including Kenmore Square)
- Segment 2: Commonwealth Avenue from Kenmore Square to Brighton Avenue (Packard's Corner)
- Segment 3: Brighton Avenue from Cambridge Street to Commonwealth Avenue.
- Segment 4: North Beacon Street from Cambridge Street to Birmingham Parkway

Traffic signals within Segments 1 through 3 (Commonwealth Avenue and Brighton Avenue) are coordinated and operated through the Boston Transportation Department's (BTD) Traffic Control Center. Many of the signalized intersections within these segments have a semi-actuated mode of operation; i.e., the main-street phases have maximum recall and show maximum green times while the side-street phases may be actuated, gap-out early, or skipped entirely. In an actuated-coordinated operation, the controller operates on a fixed cycle length, side-street phases can be skipped or gap-out early, and any unused time is transferred to the main-street phases' green time. Some of the signals operate in the fully-actuated mode; i.e., all the phases are actuated but have no maximum recall, and phases can gap-out early or be skipped entirely. None of the signalized intersections within Segment 4 is connected to the BTD traffic control system. Signals within this segment are pretimed except for the North Beacon Street and Everett Street signal. At each signalized intersection, pedestrian indications and push-buttons are provided for crossing the major road and the cross streets.

In this study an intersection is considered critical when capacity analysis indicates that one or more lane movements at the approaches is operating at LOS E or F. The type of traffic signal control and mode of operation at each critical intersection in the Boston area is provided in Table 2-2, and their locations and turning movement counts are provided in Figures 2-1 and 2-2, respectively. The intersection capacity analyses for the critical intersections are summarized in Table 2-3. The detailed analysis sheets are included in Appendix B of this report.

TABLE 2-1

Level of Service Criteria

Level of Service Criteria for Signalized and Unsignalized Intersections		
	Signalized	**Unsignalized**
Level of Service	**Average Stopped Delay (sec/veh)**	**Average Total Delay (sec/veh)**
A	≤ 5	≤ 5
B	>5 and ≤15	>5 and ≤10
C	>15 and ≤25	>10 and ≤20
D	>25 and ≤40	>20 and ≤30
E	>40 and ≤60	>30 and ≤45
F	> 60	>45

Source: 1994 Highway Capacity Manual

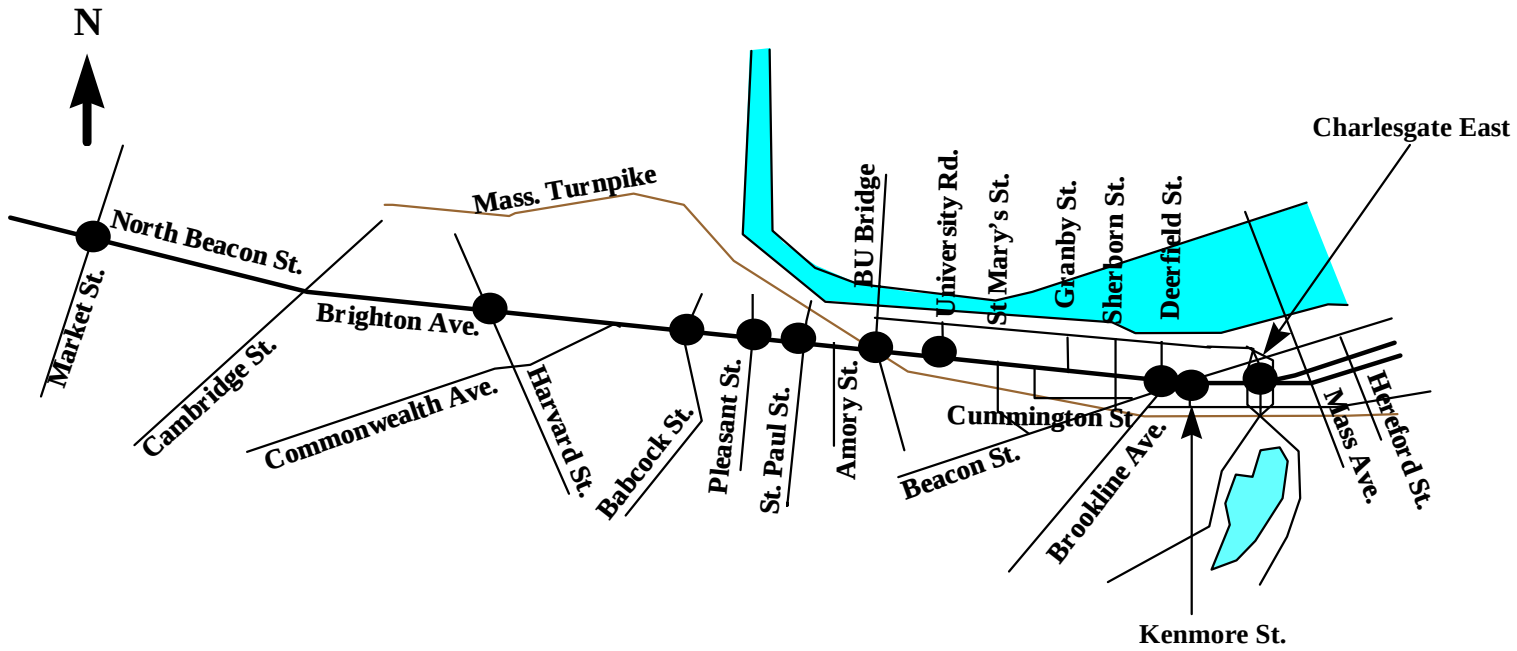
TABLE 2-2

Intersection Control Strategies and Operations at Critical Intersections Along Route 20 in Boston

INTERSECTION	Traffic Signal Control Type	Mode of Operation	Control System	Operations Trolley	Project
Commonwealth Avenue @ Charlesgate East	Semi-Actuated	Coordinated	Central computer controlled	_	_
Commonwealth Avenue @ Kenmore Street	Semi-Actuated	Coordinated	Central computer controlled	_	_
Commonwealth Avenue @ Brookline Avenue/Beacon Street	Semi-Actuated	Coordinated	Central computer controlled	_	_
Commonwealth Avenue @ University Road/Carlton Street	Semi-Actuated	Coordinated	Central computer controlled	Separate trolley indications	Commonwealth Avenue-Segment A Project
Commonwealth Avenue @ BU Bridge/Essex Street	Semi-Actuated	Coordinated	Central computer controlled	Separate trolley indications	Commonwealth Avenue-Segment A Project
Commonwealth Avenue @ Buick Street/St. Paul Street	Semi-Actuated	Coordinated	Central computer controlled	Separate trolley indications	Commonwealth Avenue-Segment A Project
Commonwealth Avenue @ Pleasant Street/H. Agganis Way	Semi-Actuated	Coordinated	Central computer controlled	No separate trolley indications	Commonwealth Avenue-Segment A Project
Commonwealth Avenue @ Babcock Street	Semi-Actuated	Coordinated	Central computer controlled	Separate trolley indications	Commonwealth Avenue-Segment A Project
Brighton Avenue @ Harvard Street	Fully-Actuated	Coordinated	Central computer controlled	_	Brighton Avenue Reconstruction Project
North Beacon Street @ Market Street	Pretimed	Isolated	Isolated	_	_

FIGURE 2-1

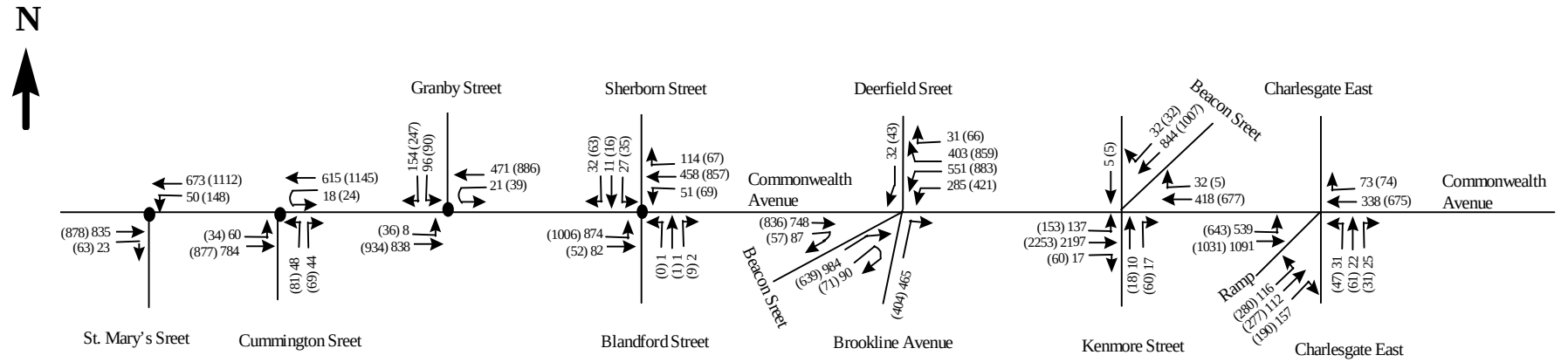
Intersections with Excessive Traffic Delays in Boston



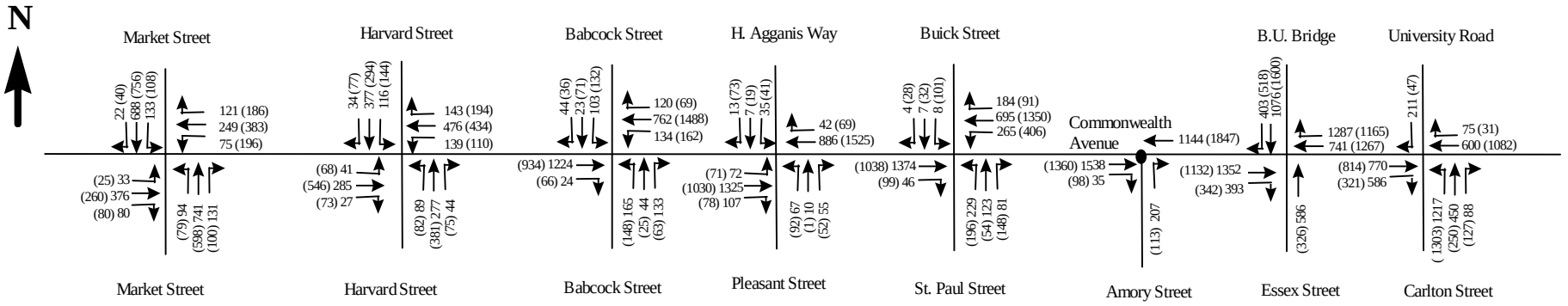
● **Signalized intersection with one or more lane movements at the approaches operating at level of service (LOS) E or F**

FIGURE 2-2

Peak Hour Turning Movement Counts at Critical Intersections in Boston



AM (PM)



- **The intersections of Commonwealth Avenue with Sherborn Street/Blandford Street, Granby Street, Cummington Street, St. Mary's Street, and Amory Street are not critical. Turning movement counts were collected at these intersections for signal coordination purpose.**

TABLE 2-3

Approach Delays and Levels of Service for Critical Intersections in Boston

		Approach Delay and Level of Service (sec/veh)			
INTERSECTION	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
Commonwealth Avenue @	AM	* (F)	-	26 (D)	22 (C)
Charlesgate East (South Roadway)	PM	* (F)	-	73 (F)	29 (D)
Commonwealth Avenue @	AM	-	21 (C)	4 (A)	-
Charlesgate East (North Roadway)	PM	-	16 (C)	14 (B)	-
Commonwealth Avenue @	AM	39 (D)	-	22 (C)	-
Kenmore Street	PM	31 (D)	-	28 (D)	-
Commonwealth Avenue @	AM	55 (E)	11 (B)	* (F)	27 (D)
Brookline Avenue/Beacon Street	PM	* (F)	8 (B)	* (F)	29 (D)
Commonwealth Avenue @	AM	9 (B)	13 (B)	13 (B)	-
University Road/Carlton Street	PM	14 (B)	19 (C)	* (F)	-
Commonwealth Avenue @	AM	21 (C)	* (F)	32 (D)	14 (B)
BU Bridge/Essex Street	PM	19 (C)	* (F)	27 (D)	26 (D)
Commonwealth Avenue @	AM	17 (C)	9 (B)	41 (E)	22 (C)
Buick Street/St. Paul Street	PM	51 (E)	20 (C)	29 (D)	* (F)
Commonwealth Avenue @	AM	* (F)	10 (B)	23 (C)	19 (C)
H. Agganis Way/Pleasant Street	PM	* (F)	16 (C)	29 (D)	23 (C)
Commonwealth Avenue @	AM	22 (C)	9 (B)	* (F)	123 (F)
Babcock Street	PM	24 (C)	31 (D)	114 (F)	92 (F)
Brighton Avenue @	AM	22 (C)	36 (D)	* (F)	* (F)
Harvard Street	PM	30 (D)	32 (D)	* (F)	* (F)
North Beacon Street @	AM	18 (C)	19 (C)	* (F)	25 (C)
Market Street	PM	17 (C)	48 (E)	15 (C)	20 (C)

Note: * Volume exceeds capacity and the calculation of delay is infeasible

Commonwealth Avenue @ Brookline Avenue/Beacon Street: Beacon Street eastbound traffic is denoted southbound.

2.2.2 Vehicular Traffic Delays at Critical Intersections Controlled by the MDC in the Route 20 Corridor

The segment of Route 20 from the point where North Beacon Street passes under the Massachusetts Turnpike in Brighton west to the point where North Beacon Street crosses the Charles River at the Brighton/Watertown town line is controlled by the MDC. In the immediate vicinity of this segment, the development along North Beacon Street is recreational; the Charles River waterfront and parks are located in this area. Recreational activities generate pedestrian and bicycle traffic during the afternoon peak period and during the weekends.

There are three signalized intersections within this segment, two of which experience excessive traffic delays during the peak periods. Figure 2-3 shows the geometric layout and lane configuration at these locations. The peak hour turning movement counts for these intersections are given in Figure 2-4. These intersections are:

1. North Beacon Street at Parsons Street and Birmingham Parkway.

2. North Beacon Street at Soldiers Field Road and Nonantum Road.

3. Nonantum Road at Brooks Street.

Presently, the levels of service at the first intersection listed above is unacceptable during the a.m. and/or p.m. peak periods (LOS F) as shown in Table 2-4. Traffic queues exist at the eastbound approach on North Beacon Street and at the northbound approach on Parsons Street. Traffic queues from this particular intersection often extend during the peak periods into the merging and weaving zone, causing safety problems (see Figure 2-3).

At the second intersection listed above, the traffic signal is failing at the southbound approach on North Beacon Street. Southbound vehicles experience significant delay during the morning peak period (LOS E or worse). Because the traffic signals in this vicinity are not synchronized, southbound traffic on North Beacon Street is sometimes released at the same time with the eastbound traffic on Nonantum Road at the intersection with Brooks Street. When this happens, both traffic streams have to weave and merge with each other to continue on North Beacon Street or Soldiers Field Road, causing safety problems.

The traffic signal at the intersection of Nonantum Road and Brooks Street operates without excessive traffic delays. However, it needs to be synchronized with the other two traffic signals listed above, to improve traffic operations in the MDC jurisdictional area.

FIGURE 2-3

Signalized Intersections Controlled by the MDC in the Route 20 Corridor

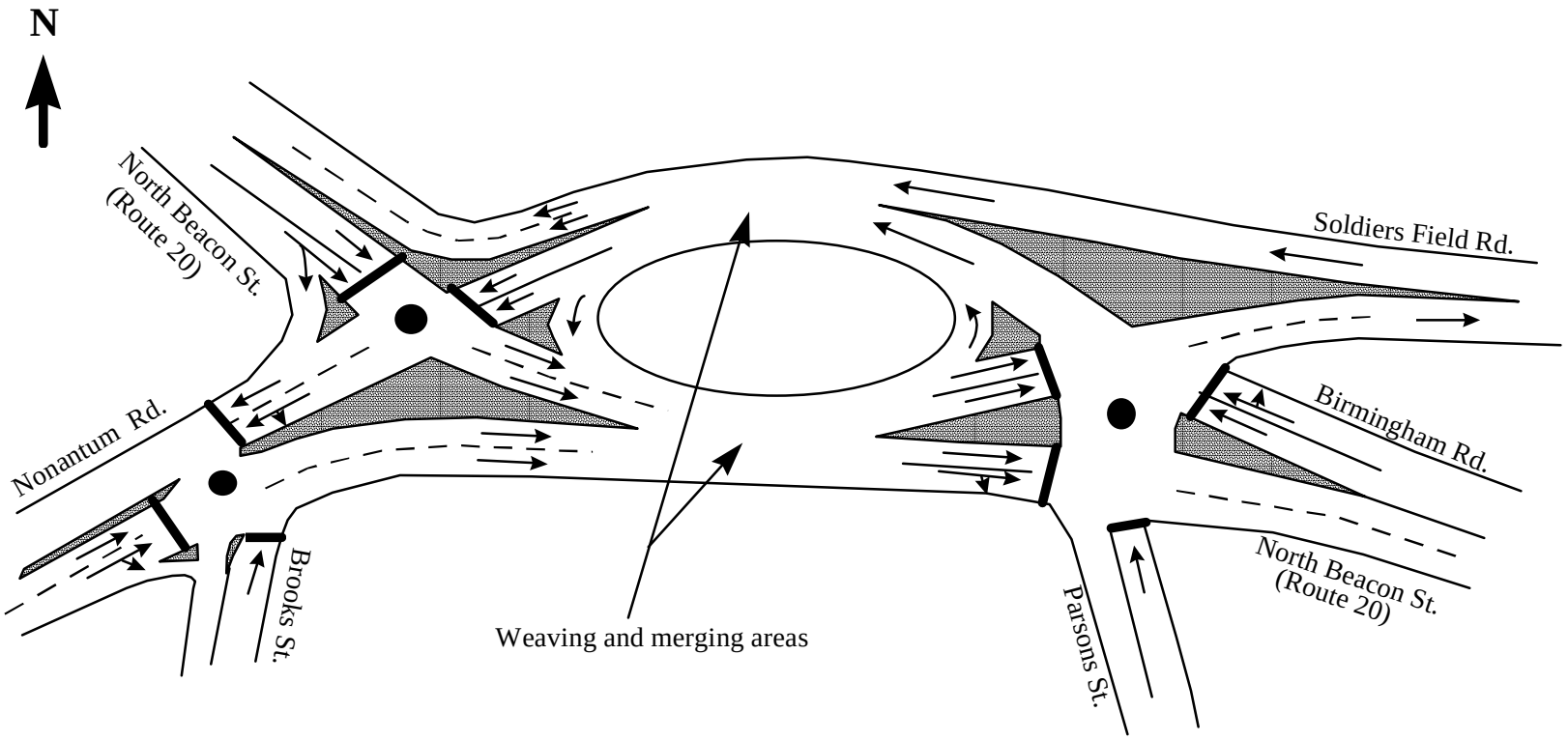


FIGURE 2-4

Peak Hour Turning Movement Counts at Critical Intersections Along Route 20 Controlled by the MDC

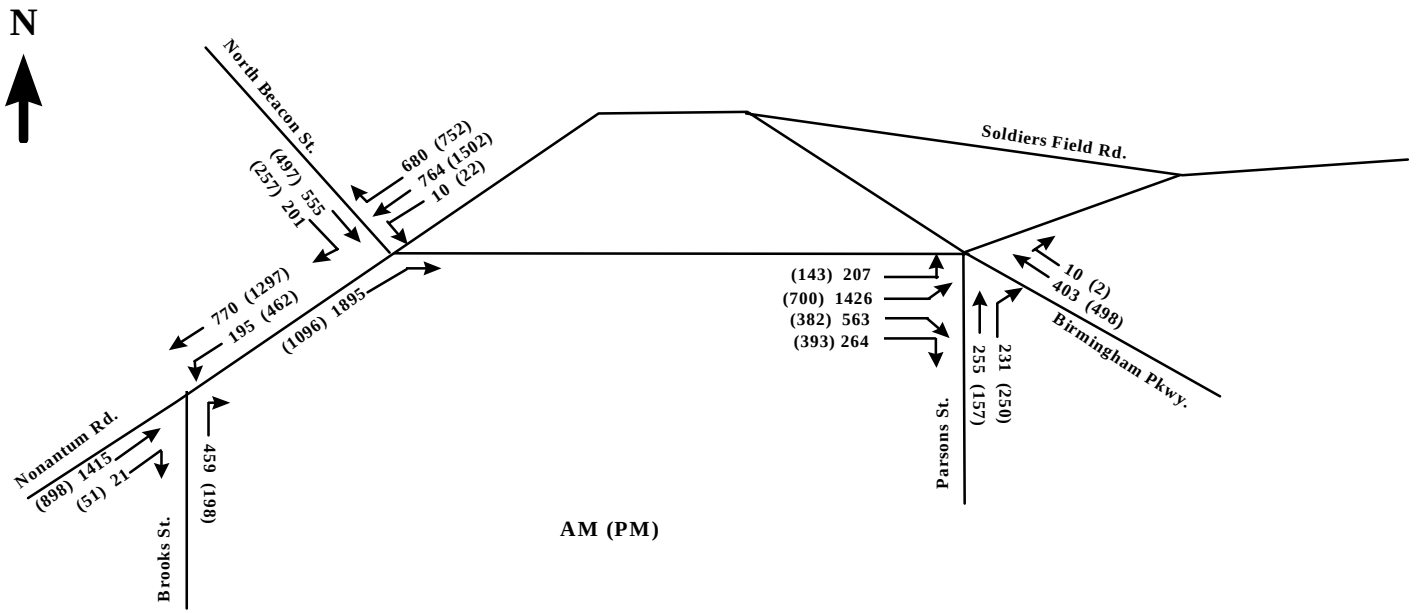


TABLE 2-4

Approach Delays and Levels of Service for Critical Intersections in the MDC Jurisdictional Area in Brighton

		Approach Delay and Level of Service (sec/veh)			
INTERSECTION	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
North Beacon Street @ Parsons Street and Birmingham Parkway	AM	* (F)	33 (D)	* (F)	_
	PM	17 (C)	35 (D)	* (F)	_
North Beacon Street @ Soldier Field Road and Nonantum Road	AM	6 (B)	_	_	41 (E)
	PM	13 (B)	_	_	28 (D)
Nonantum Road @ Brooks Street	AM	11 (B)	10 (B)	36 (D)	_
	PM	8 (B)	15 (D)	20 (C)	_

Note: * Volume exceeds capacity and the calculation of delay is infeasible

The intersection of Nonantum Road and Brooks Street is not critical, it is included here for the purpose of signal synchronization.

2.2.3 Vehicular Traffic Delays at Critical Intersections Along Route 20 in Watertown

In Watertown, three signalized intersections were identified as experiencing excessive traffic delays and affecting bus service along Route 20. They are the intersections of:

1. Main Street with Mt. Auburn Street/Galen Street/Arsenal Street/Charles River Road.
2. Main Street with Waverly Avenue/Myrtle Street.
3. Main Street with Lexington Street.

These intersections are controlled and operated by the Town of Watertown except for the Main Street and Lexington Street intersection which is controlled by MassHighway.

Traffic Delay at the Intersections of Main Street and Mt. Auburn Street/Galen Street/Arsenal Street/Charles River Road

This intersection is located in the city center, an area commonly referred to as Watertown Square (see Figure 2-5). The Watertown Square bus terminal is located on the southwest corner of this intersection and generates high volumes of bus traffic through this intersection. The intersection has five approaches; all carry high traffic volumes. All approaches have exclusive left-turn bays (Galen Street has double left-turn) and two through traffic lanes, except for the Charles River Road approach, which has a shared through-plus-left lane and shared through-plus-right lane. Bus routes 59, 70, and 71, serving Watertown and Waltham, pass through this intersection.

The current traffic signal is fully actuated and is interconnected and coordinated with the signals at the intersections of Main Street with Church Street and Pleasant Street. It is not connected, however, to surrounding traffic signals at Watertown Street/Galen Street and Arsenal Street/North Beacon Street. Pedestrian signals and phases are provided for crossing at all approaches. Access ramps and audible signals have been provided to aid people with disabilities in crossing at this intersection. Because of the high turning volumes, protected left-turn phases are provided at approaches with left-turn storage bays. The turning movement counts for this intersection are shown in Figure 2-6. During peak periods there are long queues of vehicles at all approaches, sometimes spilling into the adjacent intersections. The approach delays and levels of service are shown in Table 2-5. Presently all approaches to this intersection operate at LOS E or F except for the southbound approach.

Traffic Delay at the Intersection of Main Street and Waverly Avenue/Myrtle Street

In the immediate vicinity of the Main Street/Waverly Avenue intersection, the land use is mainly residential mixed with commercial retail. It is a four-legged intersection controlled by traffic signals. At this intersection, Main Street (Route 20) is the major route, Waverly Avenue and Myrtle Street the minor streets. All of the streets at this intersection are two-directional roadways with one lane in each direction. Bus route 70, serving Watertown and Waltham, passes through this intersection.

The traffic signal here is pretimed; i.e., it has no actuation and all phases are set to maximum recall. It is not interconnected with the adjacent signal (Main Street and Lexington Street signal) even though they are less than 2,000 feet apart. It has a three-phase plan with pedestrian-actuated push-buttons.

The peak hour turning movement counts for this intersection are provided in Figure 2-6, and the approach delays and levels of service in Table 2-5. As the table indicates, the eastbound approach operates at LOS F during both peak periods.

FIGURE 2-5

Intersections with Excessive Traffic Delays in Watertown

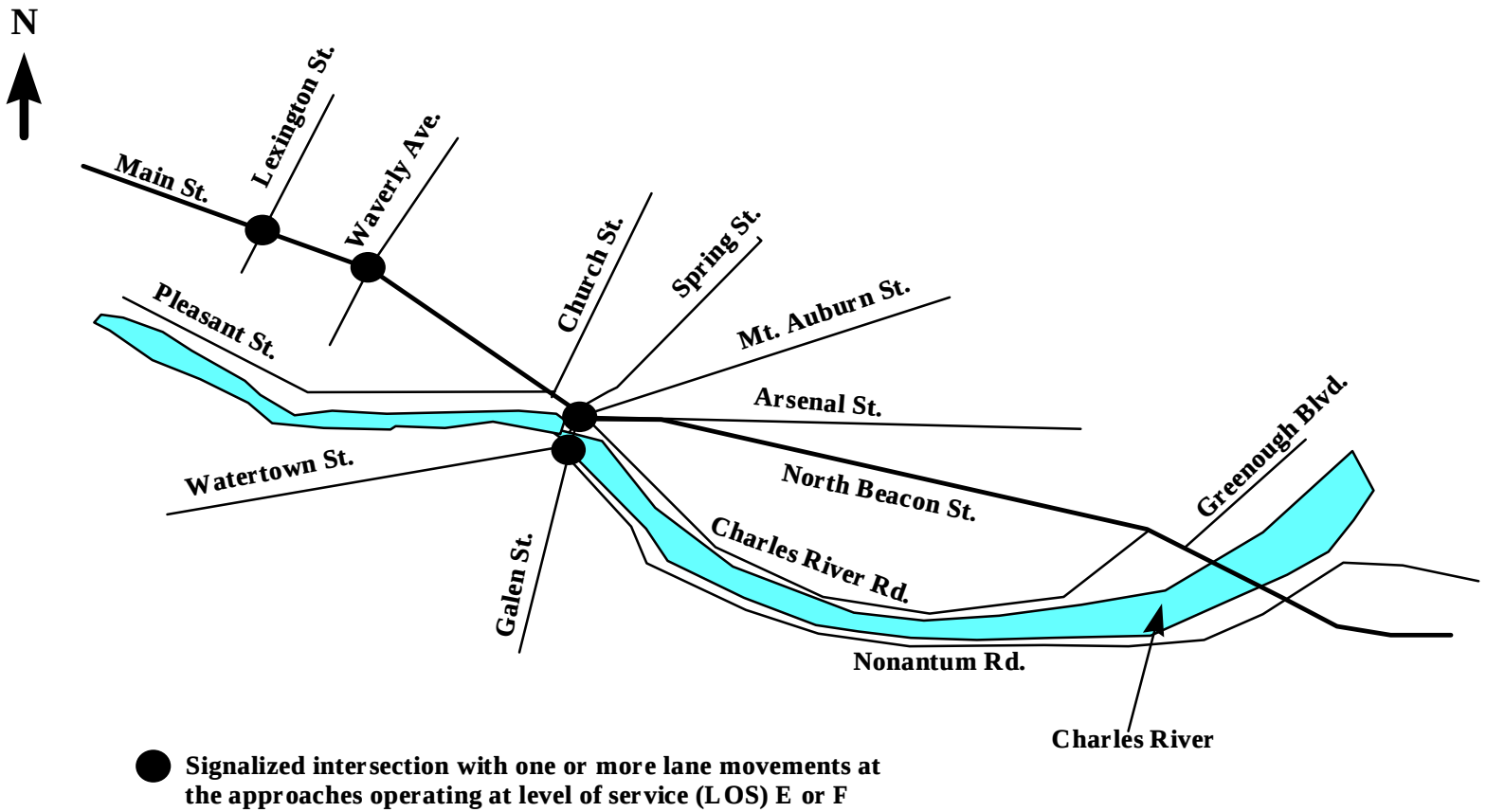
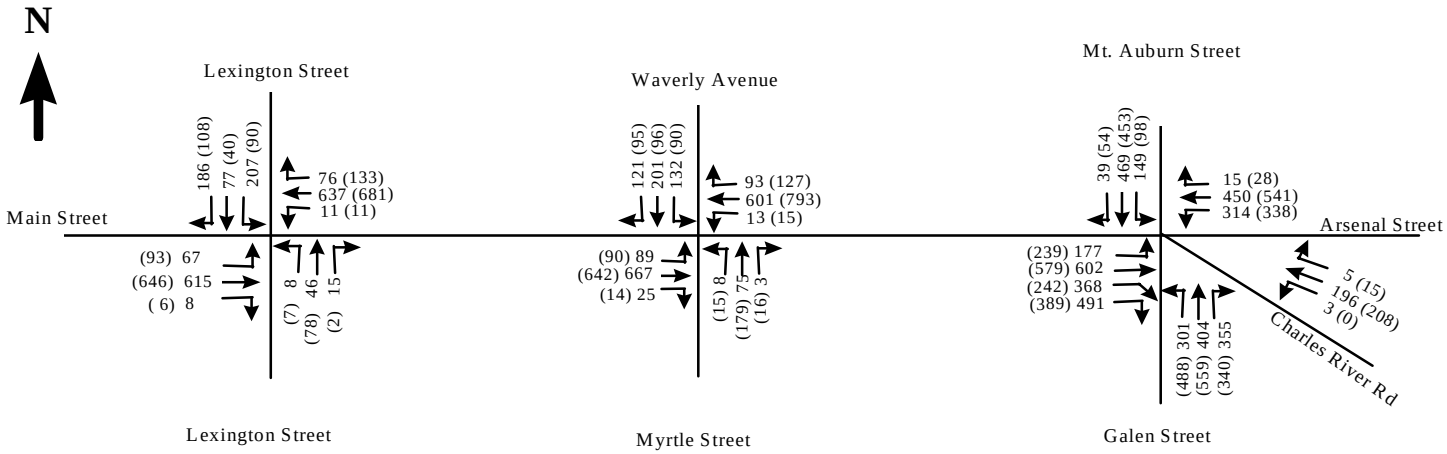


FIGURE 2-6

Peak Hour Turning Movement Counts at Critical Intersections in Watertown



AM (PM)

TABLE 2-5

Approach Delays and Levels of Service for Critical Intersections in Watertown

		Approach Delay and Level of Service (sec/veh)			
Intersection	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
Main Street @ North Beacon Street, Mt. Auburn Street, and Galen Street	AM	* (F)	* (F)	* (F)	39 (D)
	PM	* (F)	* (F)	* (F)	35 (D)
Main Street @ Waverly Avenue and Myrtle Street	AM	* (F)	10 (B)	14 (B)	* (F)
	PM	* (F)	41 (E)	16 (C)	39 (D)
Main Street @ Lexington Street	AM	* (F)	* (F)	12 (B)	54 (E)
	PM	* (F)	* (F)	15 (C)	21 (C)

Note: * Volume exceeds capacity and the calculation of delay is infeasible

Traffic Delay at the Intersection of Main Street and Lexington Street

This four-legged intersection is controlled by a traffic signal. Main Street is the major street and Lexington Street the minor street. Both streets are two-directional with one lane in each direction. In the immediate vicinity of this intersection, development is residential mixed with retail shops. Bus route 70, serving Watertown and Waltham passes through this intersection.

The traffic signal is pretimed with three phases: two vehicular traffic phases (one each for Main Street and Lexington Street) and a pedestrian-actuated phase. The adjacent traffic signal is located less than 2,000 feet from this signal, but the two signals are not interconnected and coordinated.

Field observations indicated traffic congestion during the peak periods, when the pedestrian phase is called frequently.

Peak hour turning movement counts at this intersection are provided in Figure 2-6 and the approach delays and levels of service in Table 2-5. Presently, both approaches on Main Street operate at LOS E or worse during peak periods. The southbound approach experiences significant delays during the morning peak, when it also operates at LOS E.

2.2.4 Vehicular Traffic Delays at Critical Intersections Along Route 20 in Waltham

The signalized intersections along Route 20 in Waltham are grouped into two subsystems for operational purposes. A subsystem is a group of signals interconnected and operated under a single master controller or computer. Subsystem 1 comprises all the signalized intersections along Main Street from Linden Street (Route 60) to Exchange Street. Subsystem 2 includes all the signalized intersections from Bacon Street to Eddy Street. (See Figure 2-7.) The traffic signals at the intersections of Main Street with Gore Street/Warren Street/Barbara Street are not part of these two subsystems. The traffic signal at Cedarwood Avenue on Weston Street in Waltham is also not included. This signal is controlled by MassHighway because of its close proximity to the Route 20/Route 128 interchange.

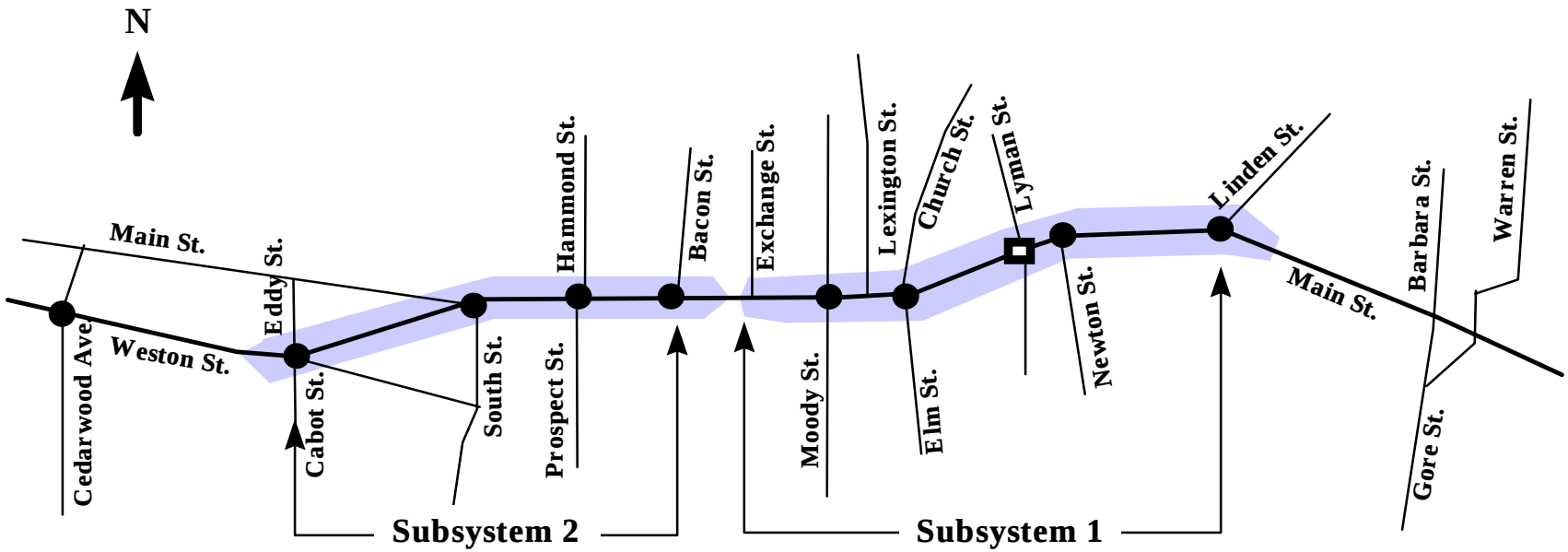
Concurrent pedestrian-actuated or exclusive pedestrian phases are provided at each of the signalized intersections. Presently, the traffic signals under these subsystems are not coordinated. They operate either as semi-actuated or fully-actuated signals. Field reconnaissance indicated traffic congestion and long queues of vehicles sometimes backing up into adjacent intersections. Because the signals are closely spaced, it is difficult to provide enough storage space for turning vehicles at some intersections without having traffic backing into adjacent intersections.

Main Street is the major street under both traffic signal subsystems. It is a two-directional roadway with one lane in each direction on most of the segments. The side streets carry significant traffic volumes. Because of the high traffic and turning volumes, the approaches on Main Street have been striped to accommodate either a left-turn and/or a right-turn storage bay at most of its intersections. On-street parking is permitted along both sides of Main Street in the city center, and because of this it is not possible to provide two traffic lanes in each direction. The main problem resulting from this is that through lanes suddenly become a right or left turn only lane at the intersections and it is very dangerous and confusing.

Ten intersections, nine of them signalized and one unsignalized, were found to experience excessive traffic delays in Waltham, as shown in Figure 2-7. Their turning movement counts are given in Figure 2-8. All signalized intersections within the two subsystems satisfy at least one of the 11 warrants for installing traffic signals. The existing approach delays and levels of service at the critical intersections (intersections with one or more approaches operating at LOS E or LOS F during the peak periods) are given in Table 2-6.

FIGURE 2-7

Intersections with Excessive Traffic Delays in Waltham

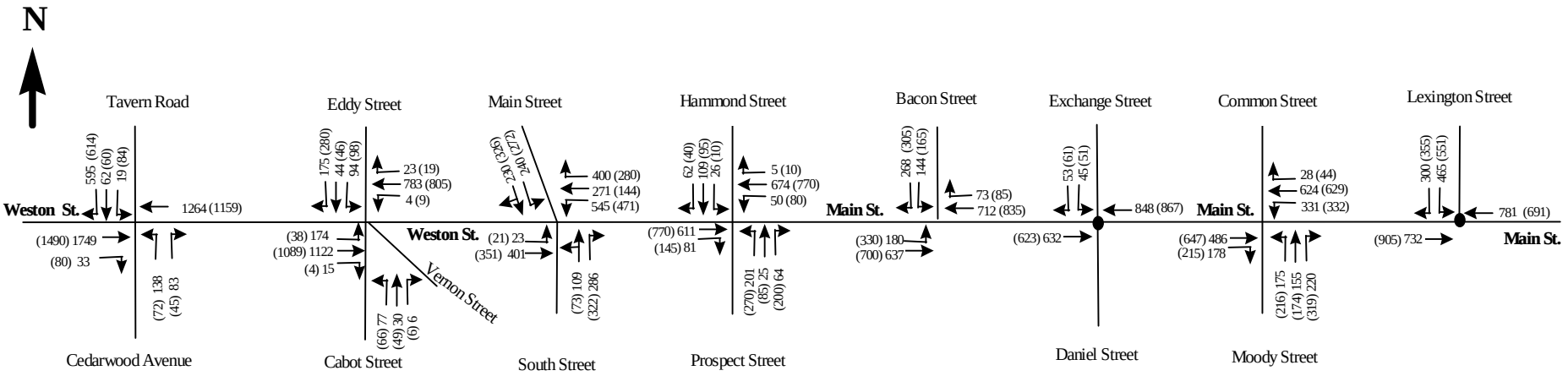


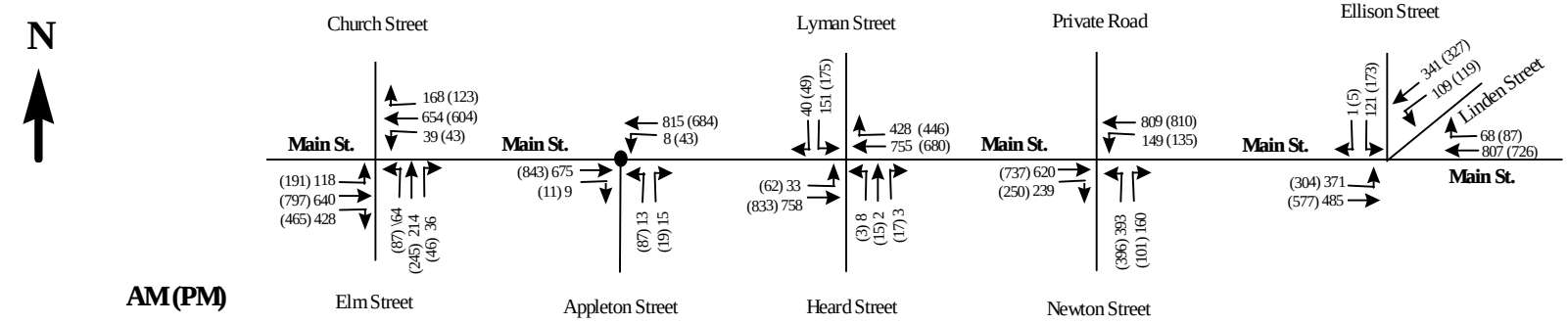
Signalized intersection with one or more lane movements at the approaches operating at level of service (LOS) E or F

Unsignalized intersection with one or more lane movements at the approaches operating at level of service (LOS) E or F

FIGURE 2-8

Peak Hour Turning Movement Counts for Critical Intersections Along Route 20 in Waltham





- **The intersections of Main Street with Exchange Street/Daniel Street, Lexington Street, and Pleasant Street are not critical. Turning movement counts were collected at these intersections for signal coordination purpose.**

TABLE 2-6

Approach Delays and Levels of Service for Critical Intersections in Waltham

		Approach Delay and Level of Service (sec/veh)			
Intersection	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
Main Street @	AM	19 (C)	12 (B)	_	40 (D)
Linden Street and Ellison Park	PM	11 (B)	11 (B)	_	33 (D)
Main Street @	AM	21 (C)	69 (F)	* (F)	_
Newton Street	PM	30 (D)	20 (C)	* (F)	_
Main Street @ Lyman Street/Heard Street	AM	1 (A)	_	31 (E)	* (F)
(Unsignalized Intersection)	PM	1 (A)	_	36 (E)	* (F)
Main Street @	AM	13 (B)	38 (D)	22 (C)	_
Elm Street and Church Street	PM	16 (C)	28 (D)	23 (C)	_
Main Street @	AM	20 (C)	36 (D)	19 (C)	_
Moody Street and Common Street	PM	22 (C)	38 (D)	21 (C)	_
Main Street @	AM	19 (C)	24 (C)	_	46 (E)
Bacon Street	PM	29 (D)	40 (E)	_	43 (E)
Main Street @	AM	22 (C)	18 (C)	26 (D)	33 (D)
Prospect Street and Hammond Street	PM	34 (D)	21 (C)	41 (E)	33 (D)
Main Street @ South Street/Weston Street	AM	28 (D)	26 (D)	34 (D)	* (F)
EB Main Street is denoted Southbound	PM	14 (B)	12 (B)	23 (C)	* (F)
Weston Street @	AM	16 (C)	58 (E)	37 (D)	* (F)
Eddy Street, Vernon Street, and Cabot St.	PM	30 (D)	12 (B)	* (F)	* (F)
Weston Street @	AM	* (F)	19 (C)	15 (C)	20 (C)
Cedarwood Avenue and Tavern Road	PM	45 (E)	16 (C)	14 (B)	20 (C)

Note: * Volume exceeds capacity and the calculation of delay is infeasible

2.2.5 Inconsistent Lane Assignments

Inconsistent lane assignments are those that trap straight-through vehicles in right-only or left-only turn lanes without adequate warning. They interrupt traffic flow and reduce the capacity of both roadway and intersection. At certain locations along Route 20 in Waltham, inconsistent lane assignments (particularly, right-only and left-only turn bays) force two lanes of moving traffic to squeeze into one, resulting in severe congestion and safety problems. Motorists and bicyclists keep changing lanes to avoid being trapped, an unsafe practice when it happens too frequently.

One location experiencing this problem is the Main Street eastbound approach at the intersection with Elm Street, as shown in Figure 2-9. Owing to the intersection's geometric layout and lane assignments, through traffic in the eastbound direction is often trapped in the right-turn lane and blocks traffic until able to change lanes (move into the middle lane) to proceed through the intersection. Another location of concern in Waltham is the segment of Main Street between Bacon and Hammond streets. This segment has substandard turn lanes, and not enough signing is provided to warn motorists of lane assignment at the next intersection.

2.2.6 Intersection Safety Problems

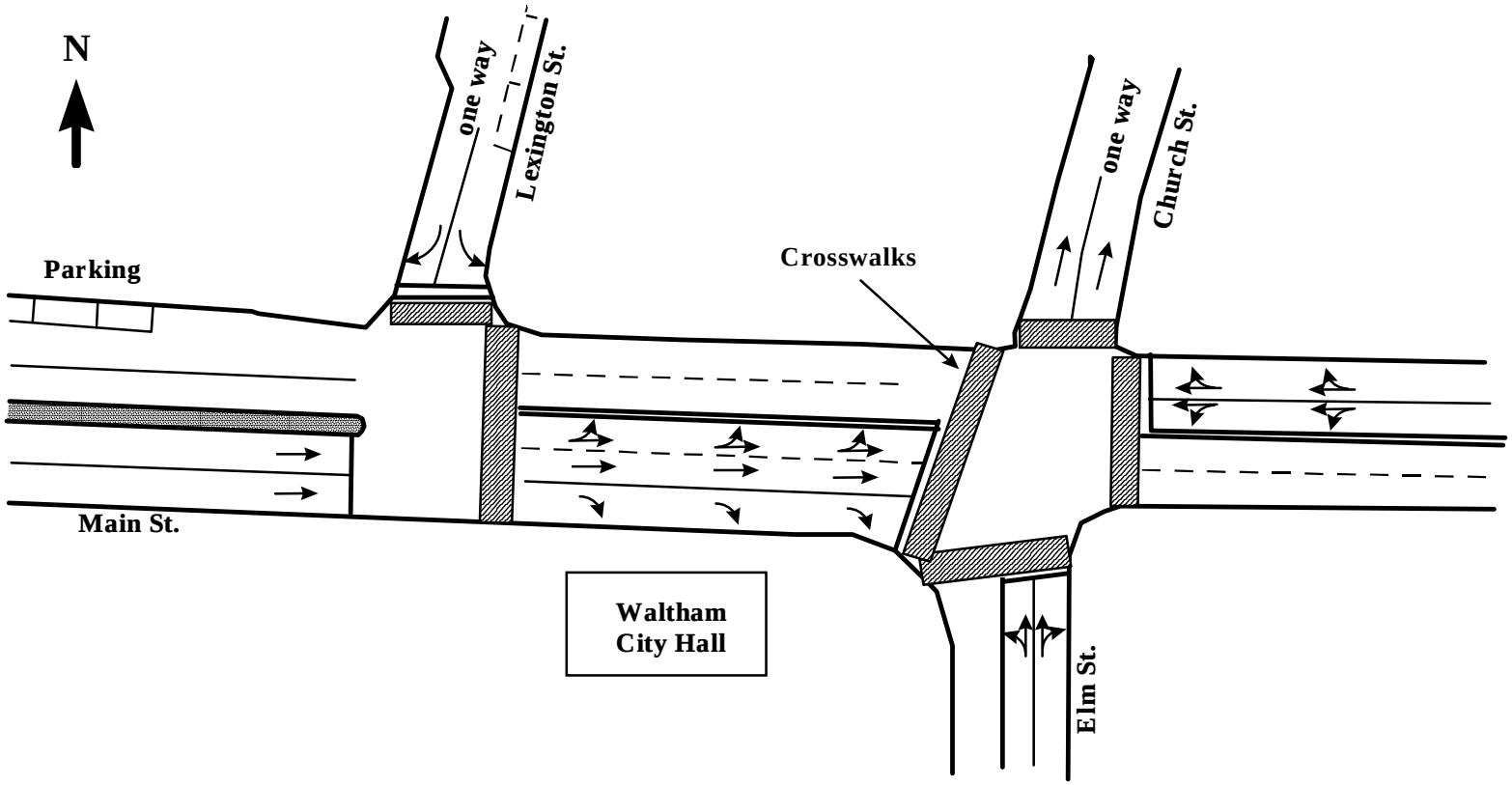
Most traffic signal indications along Route 20 are well understood by motorists and comply with the Manual on Uniform Traffic Control Devices (MUTCD). However, motorists complain of confusing signal indications at these two intersections in Waltham: (1) Main Street at Linden Street and (2) Weston Street at Cedarwood Avenue/Tavern Road. Two other safety issues identified in Waltham involve: (1) traffic operations and safety at the Banks Square intersection and (2) access and signage at the intersection of Weston Street and Livingstone Lane/Sibley Road and at the Route 20/Route 128 rotary interchange.

Signal Indication Problem at Main Street and Linden Street in Waltham

At this intersection, when the green for the eastbound through traffic on Main Street comes on, there is always a circular red indication accompanying it at the top (see Figure 2-10). This indication, although approved by the MUTCD, confuses motorists; they do not know whether to stop or to proceed. Even though there is an exclusive left-turn bay at this intersection, the left-turn signal face is shared with the straight-through traffic. An auxiliary left-turn sign, "NO LEFT TURN ON THRU ARROW," post-mounted in the median facing the eastbound traffic is used to warn motorists turning left from this approach. However, this auxiliary left turn sign does not resolve the confusion. The problem wastes precious green time and causes drivers to make unsafe maneuvers, as motorists who are familiar with this situation pull out of the through lane to pass vehicles in front of them. For the three-year period 1994-1996, 57 motor vehicle accidents were reported to the police at this intersection (22 in 1994, 23 in 1995, and 12 in 1996). Improved signal indication sequences are needed to address this problem.

FIGURE 2-9

Inconsistent Lane Assignment at the Intersection of Main Street and Elm Street/Church Street in Waltham



Signal Indication Problems at the Intersection of Weston Street, Cedarwood Avenue, and Tavern Road in Waltham

This signalized intersection controlled by MassHighway is located in a residential neighborhood in Waltham. Weston Street is the major street, with two travel lanes in each direction. Currently the traffic signals are failing during both peak periods. During the morning peak, the eastbound traffic queue extends back into the Route 20/Route 128 rotary interchange. The westbound traffic queue sometimes spills over to the Stow Street intersection during the afternoon peak period.

Left-turn maneuvers are prohibited from the Weston Street westbound approach at the intersection of Cedarwood Avenue and Tavern Road. Only through movements are allowed from this approach due to the poor sight distance and other safety concerns such as speeding. Because left-turn maneuvers are prohibited from this approach, they are not protected from the oncoming eastbound through traffic. Motorists making this illegal left-turn maneuver block westbound through traffic, causing congestion during the peak periods.

Complaints from residents indicate that some drivers ignore the auxiliary left-turn prohibition sign and turn left (see Figure 2-11). The cause of this problem is that some drivers interpret the present circular green indications to allow left turns as well as through movements. In 1994-1996, 36 motor vehicle accidents were reported to the police at this intersection (15 in 1994, 12 in 1995, and 9 in 1996).

Currently, to get onto Cedarwood Avenue from Weston Street westbound, one has to turn right at the preceding intersection onto Stow Street, turn left from Stow Street onto Tavern Road, and proceed straight on Tavern Road onto Cedarwood Avenue. An improved traffic signal indication in addition to the present auxiliary left-turn sign, is needed to improve traffic operations at this intersection.

Safety Problems at Banks Square in Waltham

Banks Square is the intersection of Main Street/Weston Street/South Street (see Figure 2-12). It is a signalized intersection controlled by the City of Waltham. The major streets are Main Street and Weston Street, each having two travel lanes in each direction. Both major streets and the minor street carry high traffic volumes during the peak periods. Presently the intersection experiences cycle failures in the peak periods due to the heavy demand. At this intersection, westbound vehicles on Main Street turning left onto South Street create a safety problem for Main Street traffic proceeding west onto Weston Street. This problem arises when the westbound through traffic which is blocked by the left-turning vehicles (left turns are permitted by the phasing) decide to pull out into the right lane to proceed through the intersection (see Figure 2-12). For the three-year period 1994-1996, only three motor vehicle accidents were reported to the police at this intersection. However, a signal phasing plan that will improve both safety and efficiency should be implemented to address the problem.

FIGURE 2-10

Signal Indications Shown to Motorists at the Eastbound Approach of Main Street and Linden Street Intersection in Waltham

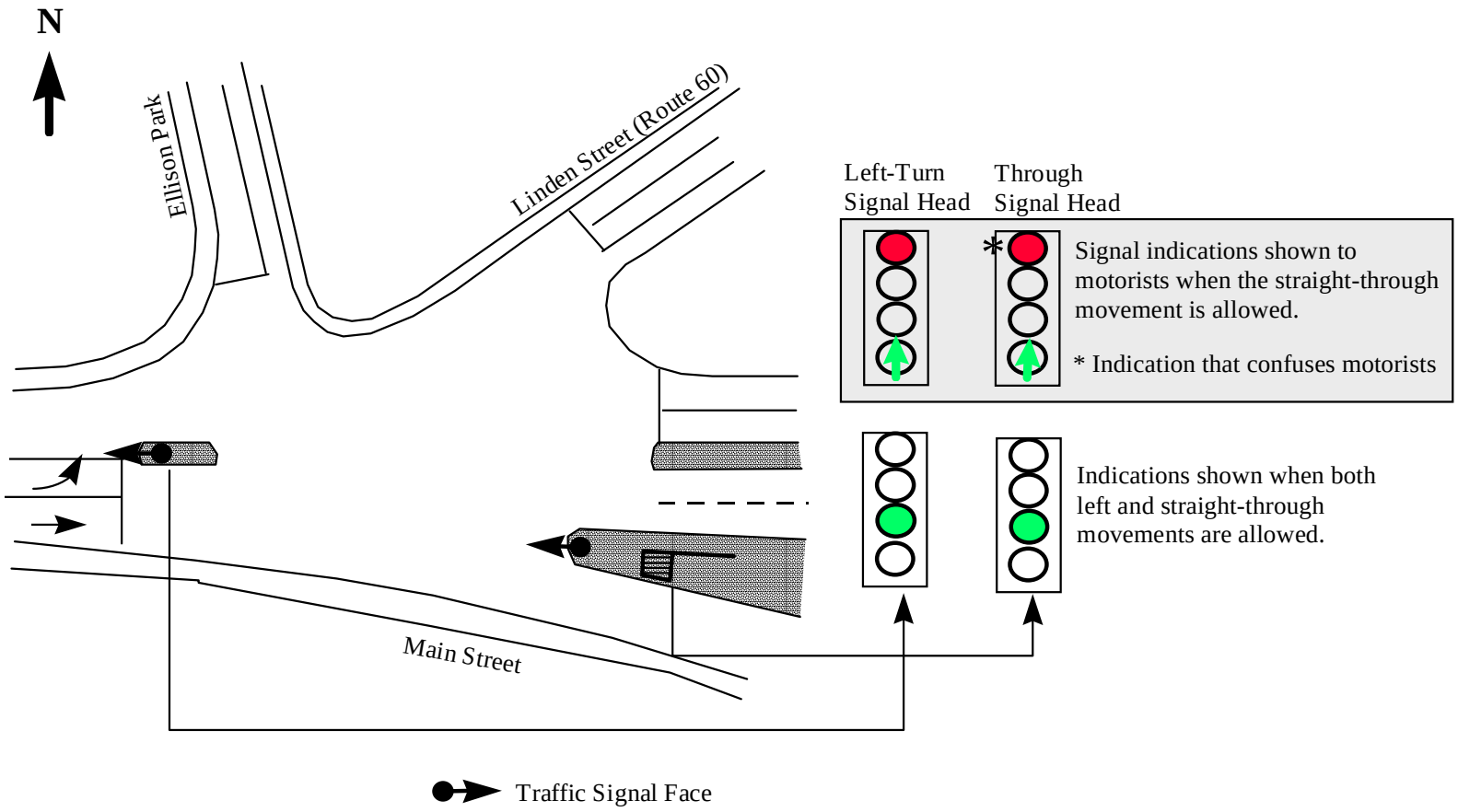


FIGURE 2-11

Signal Indications at the Westbound Approach of Weston Street and Cedarwood Avenue/Tavern Road Intersection in Waltham

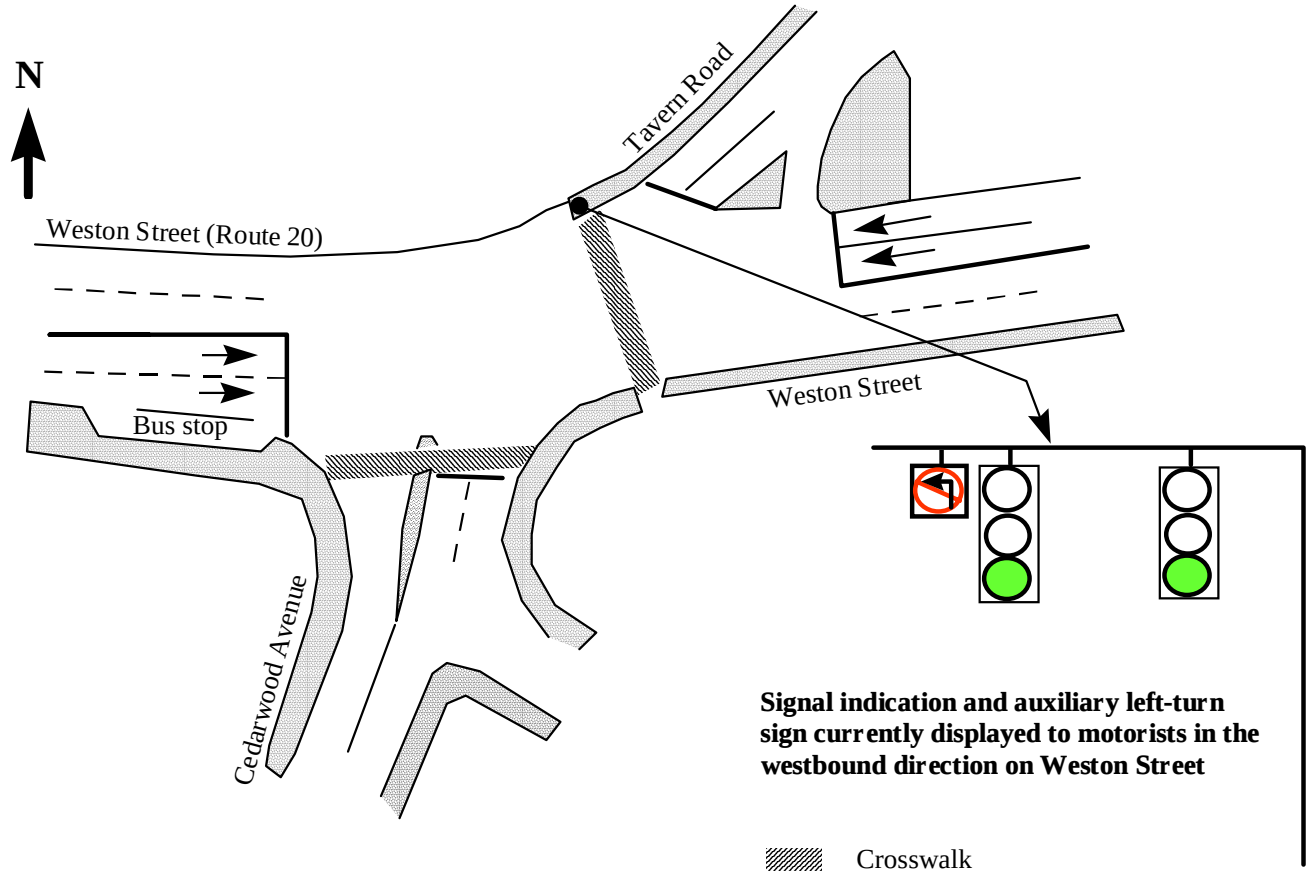
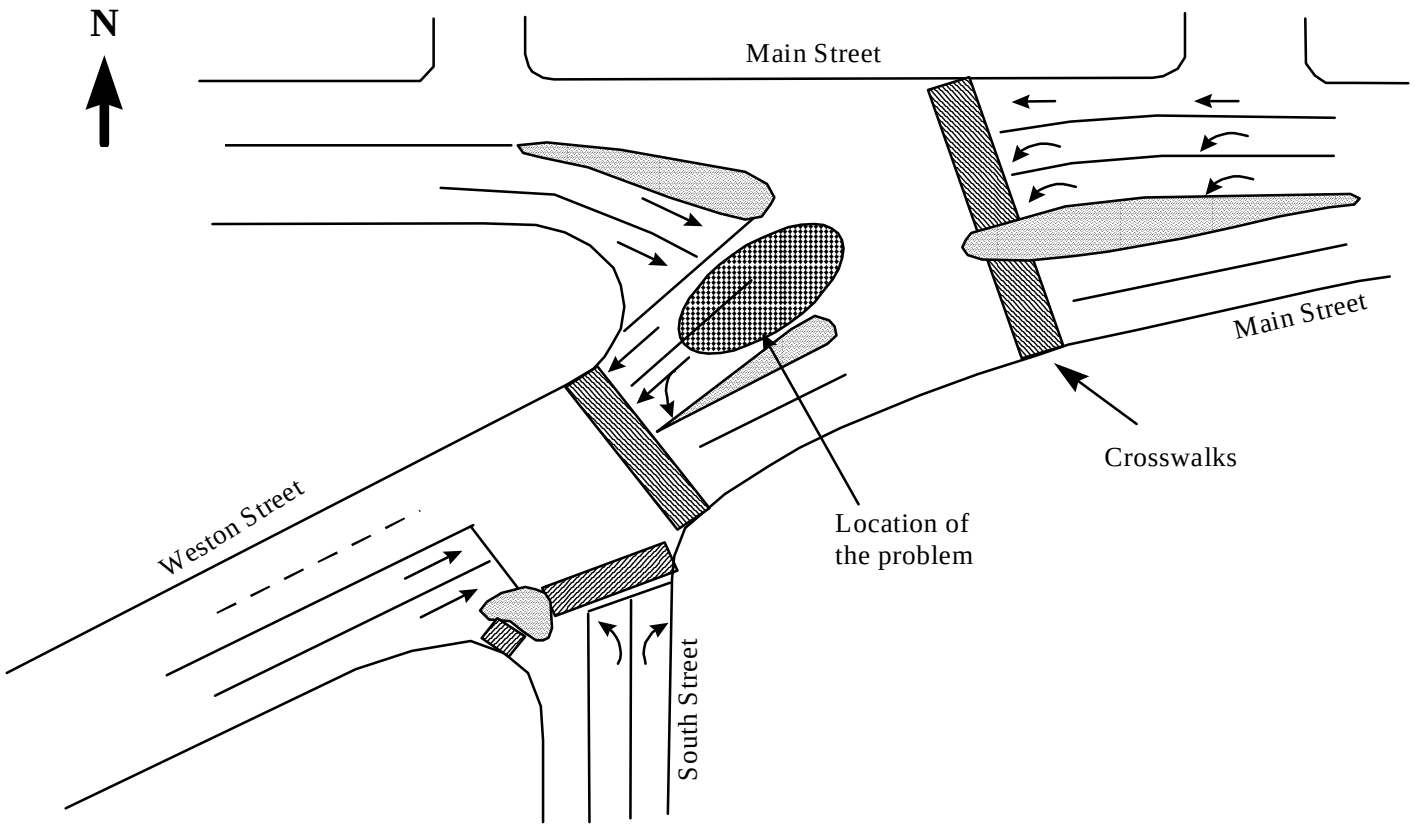


FIGURE 2-12

Banks Square Intersection in Waltham



Safety Issues at the Intersection of Weston Street and Livingstone Lane/Sibley Road in Waltham

This unsignalized intersection, located near the Route 20/Route 128 rotary interchange in a residential neighborhood in Waltham, is controlled by MassHighway (see Figure 2-13). Weston Street is the major road, with two travel lanes in each direction. Livingstone Lane is a short residential street that turns into a cul-de-sac at its end; it can only be accessed from Weston Street. Sibley Road connects to the Brandeis University and surrounding recreational areas. Traffic from both side streets is very light and does not meet the warrants for installing traffic signals. Also, because this intersection is so close to the Route 20/Route 128 rotary interchange, it precludes installation of a traffic signal.

Presently, residents find it difficult to get out of Livingstone Street because of the high speed, poor sight distance, and high volume of traffic on Weston Street. During the morning peak period, the high traffic volume going westbound on Weston Street and the traffic queue extending from the Weston Street/Cedarwood Avenue/Tavern Road intersection make it virtually impossible to turn left from Livingstone Street. For the same reasons it is also difficult to turn left from Sibley Road onto Weston Street westbound.

The side road sign (W2-3) and the 30 mph speed limit sign on Weston Street westbound direction intended to warn motorists of the presence of an obscured side street and to slow down, do not give drivers enough time, because they are located too close to Livingstone Lane. Anyone attempting to slow down on Weston Street to make a right turn onto Livingstone Lane, run the risk of a rear-end collision. Not only is the traffic accelerating at this point (near Livingstone Lane) but it is also merging. The entrance to Livingstone Lane is fairly narrow, and one has to slow down to a crawl before making a right turn from Weston Street.

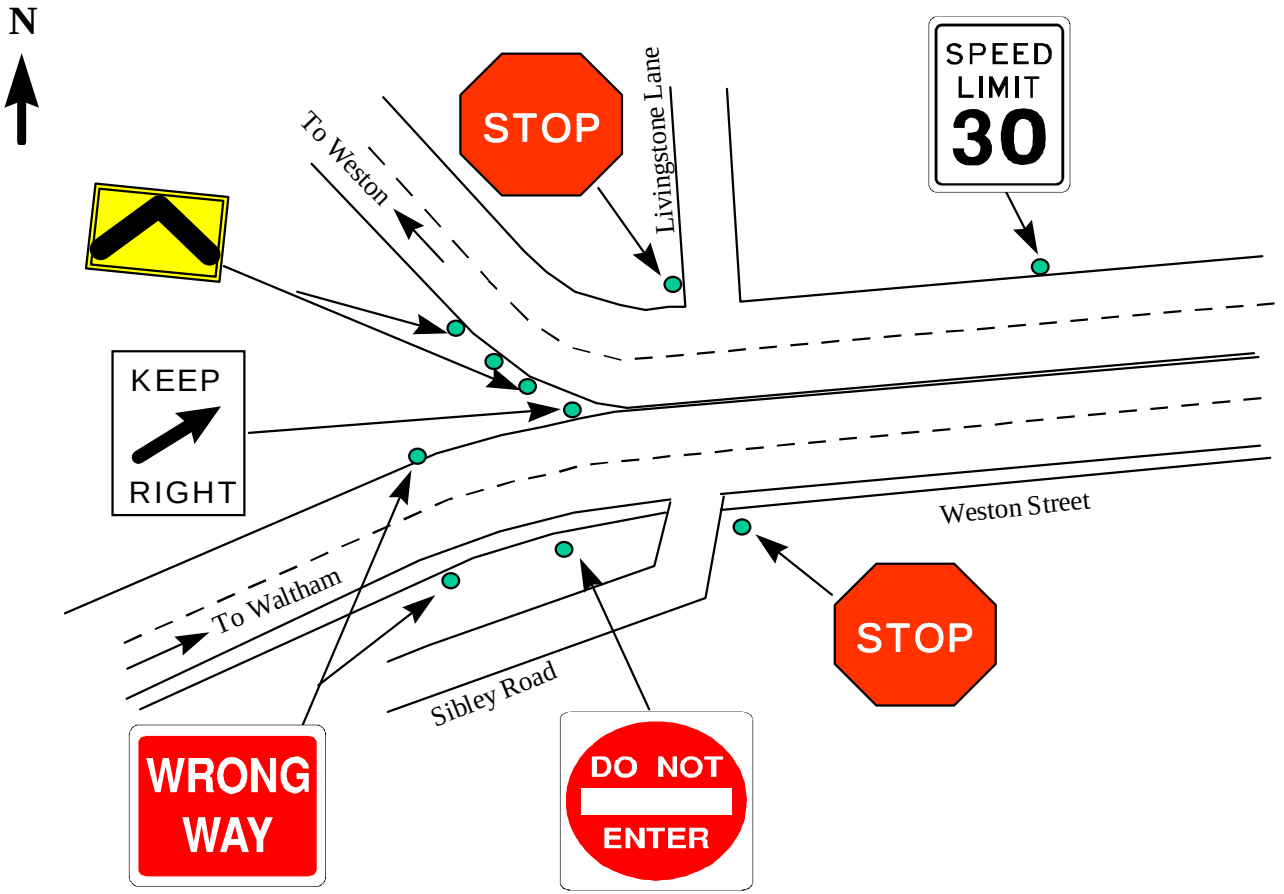
Signage at the Route 20/Route 128 Rotary Interchange in Waltham

Signing at the westside of the Route 20/Route 128 rotary interchange needs some improvements. During a public meeting it was pointed out that sometimes Weston Street westbound drivers enter the wrong way to get to Route 128. This maneuver can result in severe head-on collisions with Weston Street eastbound vehicles. Other complaints include speeding and placement of signs. The sign “KEEP RIGHT”, with an arrow (R4-7b) installed in the median at the westbound entry point to the Route 20/Route 128 rotary interchange is mounted too low to the ground. This sign is frequently run down by Weston Street westbound vehicles traveling at high speeds that fail to negotiate the curve in that vicinity (see Figure 2-13).

Another problem at the Route 20/Route 128 rotary interchange is that a significant proportion of traffic coming north on Route 128 exiting to Route 20 sometimes disregard the yield sign and merge directly with Route 20 eastbound traffic at speeds of 40 to 50 mph. This poses a safety problem because of the high volume of traffic on both Route 20 and the ramp. Currently, the speed limit on Route 20 in this vicinity is posted at 35 mph.

FIGURE 2-13

Signage at the Interesection of Weston Street, Livingstone Lane, Sibley Road, and Route 20/Route 128 Rotary Interchange in Waltham



2.2.7 On-Street Parking Problems

Route 20 serves land use purposes that require on-street parking. Several of its segments have on-street parking that serve commercial, institutional, and residential land use activities. On-street parking is permitted over almost the entire length of Route 20 in the Boston area due to these needs. Most of the on-street parking on Route 20 in Waltham and Watertown is within the city centers, serving mainly commercial activities. The on-street parking spaces are metered, operated, and managed by the cities. Many of them are for short-term parking (ranging from one to two hours).

Figure 2-14 shows the locations with double-parking problems and other illegal parking problems along Route 20 in the Boston area. At certain locations the parking supply is not adequate, forcing motorists either to double-park or park at prohibited locations. This behavior affects the safety of both vehicular and bicycle traffic. It reduces the capacity of the roadway, blocks sight distances at the intersections, and causes drivers to make unsafe lane changes. Problem locations documented during our field reconnaissance are:

1. Commonwealth Avenue between Arlington Street and Massachusetts Avenue in Boston.

2. Kenmore Square in Boston.

3. Commonwealth Avenue between Sherborn Street and Babcock Street in Boston.

4. North Beacon Street and Brighton Avenue (Union Square) in Brighton.

Double-Parking Along Commonwealth Avenue Between Arlington Street and Massachusetts Avenue in Boston

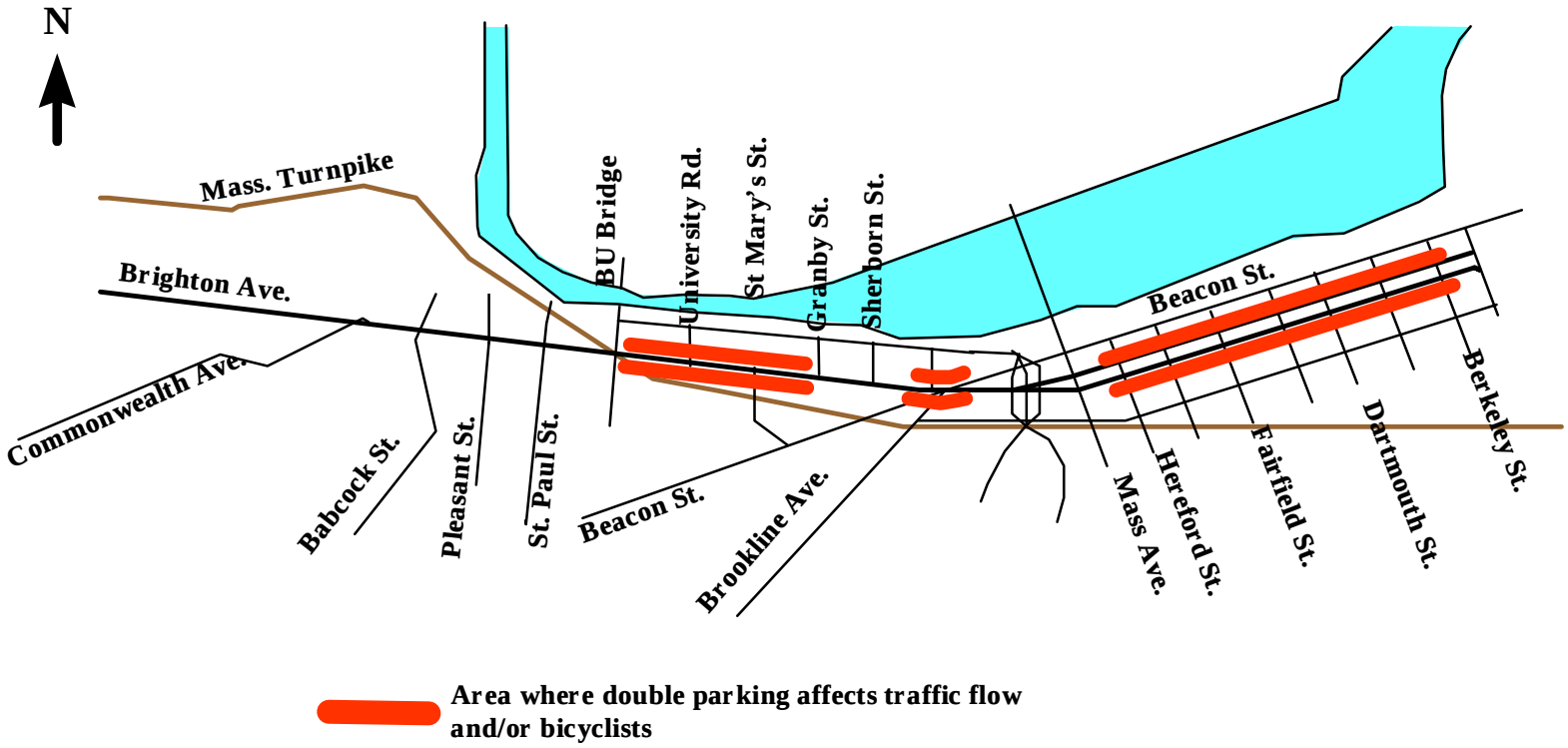
This segment of Route 20, located in a residential setting, experiences tremendous double-parking both during peak and off-peak periods. The limited availability of structured and off-street parking forces residents, visitors, delivery people, and maintenance people to double-park their vehicles in order to carry out their activities (see Figure 2-14). During peak periods, this affects traffic flow and the safety of bicyclists and motorists.

Double-Parking at Kenmore Square in Boston

Kenmore Square is the complex intersection of Commonwealth Avenue, Beacon Street, Brookline Avenue, Kenmore Street, Raleigh Street, and Deerfield Street. This large and busy intersection has the MBTA bus terminal sitting in the middle of it. The MBTA portals provide connections between the sidewalks and the surface bus station, as well as the Green Line subway

FIGURE 2-14

Locations with Illegal and Double Parking along Commonwealth Avenue in Boston



station beneath it. Both stations and commercial activities generate high volumes of bus and pedestrian traffic. Also, the intersecting streets carry high traffic volumes, and the whole intersection is failing during the peak periods. Vehicles double-parking in this area cause traffic congestion in both the eastbound and westbound directions on Commonwealth Avenue.

Illegal and Double Parking Along Commonwealth Avenue Between Sherborn Street and Babcock Street in Boston

This segment of Route 20 through Boston University experiences both illegal parking and double-parking which disturbs traffic flow and limits drivers' sight distances at intersections, which is of special concern at those with pedestrian crosswalks. The B Branch of the MBTA Green Line, which runs in the median on Commonwealth Avenue, generates and attracts many passengers, all of whom use pedestrian crosswalks to cross Commonwealth Avenue to board the trains and leave the platforms.

Parking statistics for this area collected by Howard/Stein-Hudson Associates between November 1994 and January 1995 and by Bruce Campbell & Associates in May 1996 are shown in Tables 2-7 and 2-8. As these tables show, the commercial and student activities in this area generate illegal on-street parking with high turnover rates. Improvements are needed to prevent double parking and also serve the high parking turnover rates.

Illegal Parking on North Beacon Street between Cambridge and Everett Streets in Brighton

At Union Square, Route 20 changes name, from Brighton Avenue to North Beacon Street. This intersection was redesigned and improved as a result of the Brighton Avenue Road Reconstruction project in 1996. The approaches on both Brighton Avenue and North Beacon Street in the present lane configuration have two straight-through travel lanes; the outbound or departure lanes also have two travel lanes. All intersecting streets carry high traffic volumes and have one or more bus routes. Union Square also serves as a transfer point between bus Routes 57 and 66, bus Routes 64 and 66, and bus Routes 57 and 64.

Illegal parking at the westbound departure lanes on North Beacon Street forces two lanes of westbound through traffic to squeeze into one lane, as shown in Figure 2-15. This bottleneck causes the westbound traffic to queue, blocking the whole intersection. During peak periods this blockage sometimes prevents traffic on Cambridge Street from moving even when it is shown green indications. Route 64 buses are also trapped in the intersection due to merging traffic.

TABLE 2-7

Double-Parking and Illegal Parking Statistics Along Commonwealth Avenue in the Boston University Area: Westbound

Westbound(Outbound)	Land Use	No. of Parking Spaces	Double-Parking	Illegal Parking
Deerfield St. to Sherborn St.	Commercial/Institutional	14	0	0
Sherborn St. to Granby St.	Commercial/Institutional	25	13	1
Granby St. to University Rd	Institutional	60	66	28
University Rd to BU Bridge	Institutional	-	-	-
BU Bridge to Buick St.	Institutional	50	6	2
Buick St. to H. Agganis Way	Institutional	24	0	3
H. Agganis Way to Babcock St.	Commercial/Institutional	20	9	24
Babcock St. to Alcorn St.	Commercial	13	5	18

Data collected from 7:00 AM-7:00 PM (12 hours)
Source: Bruce Campbell & Associates, Inc., and Howard/Stein-Hudson Associates

TABLE 2-8

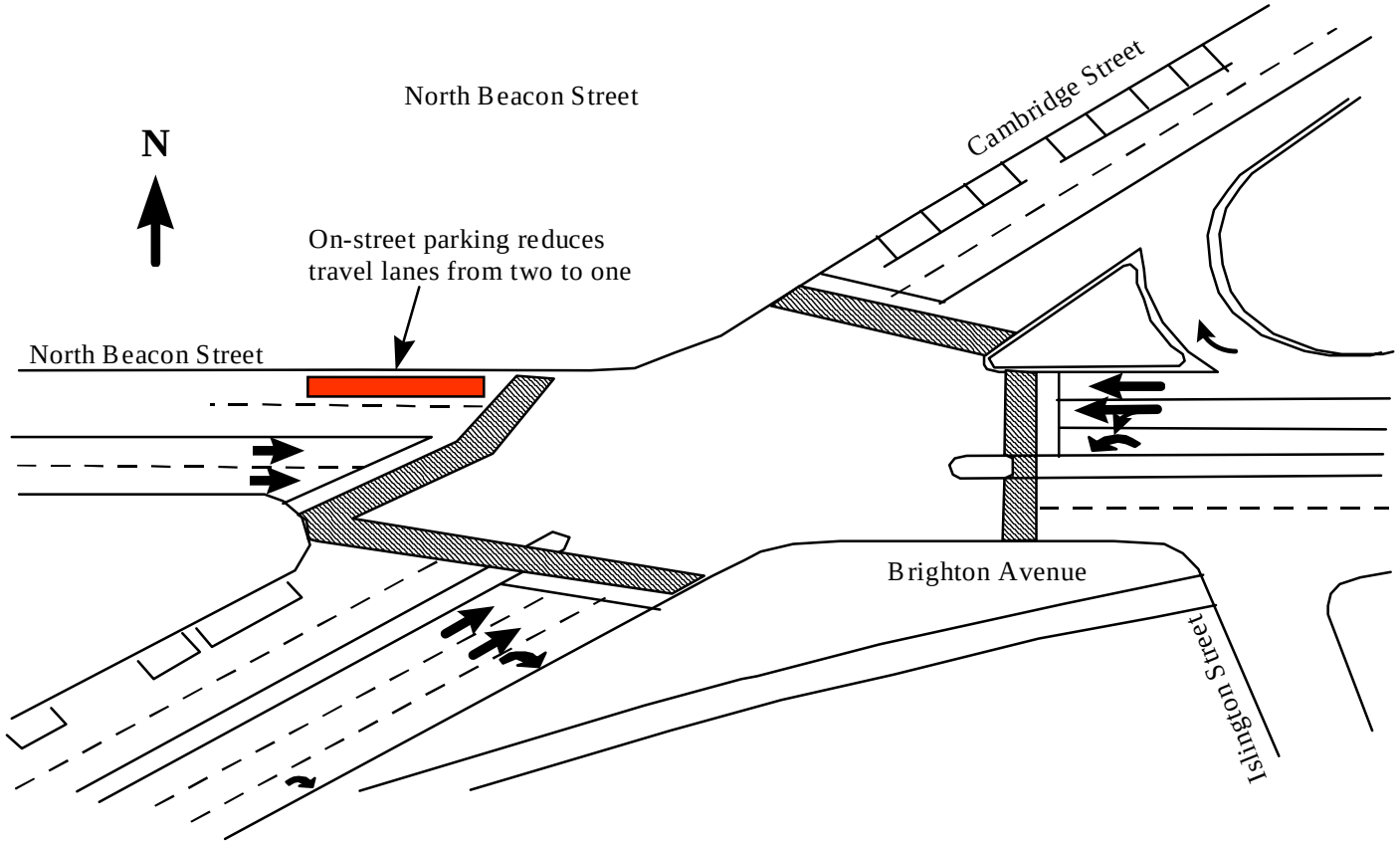
Double-Parking and Illegal Parking Statistics Along Commonwealth Avenue in the Boston University Area: Eastbound

Eastbound (Inbound)	Land Use	No. of Parking Spaces	Double-Parking	Illegal Parking
Babcock St. to Pleasant St.	Commercial/Institutional	13	-	15
Pleasant St. to St. Paul St.	Commercial	18	6	24
St. Paul St. to Amory St.	Commercial	19	4	5
Amory St. to Essex St.	Commercial	25	1	8
Essex St. to Carlton St.	Overpass	-	-	-
Carlton St. to St. Mary's St.	Commercial	14	11	8
St. Mary's St. to Cummington St.	Commercial/Institutional/ Residential	15	15	9
Cummington St. to Hinsdale St.	Commercial/Institutional/ Residential	21	28	2
Hinsdale St. to Blandford St.	Institutional	25	5	1
Blandford St. to Beacon St.	Commercial/Institutional/ Residential	23	1	13

Data collected from 7:00 AM-7:00 PM (12 hours).
Source: Bruce Campbell & Associates, Inc., and Howard/Stein-Hudson Associates

FIGURE 2-15

Illegal Parking at Union Square in Brighton



On-Street Parking Along Main Street Between Lexington Street and Moody Street in Waltham

In 1993, as part of the Waltham Central Square, Urban Systems Street Reconstruction Project, on-street parking was restored at certain locations on Main Street (Route 20) to improve access to downtown businesses. At that time, traffic volumes were at such levels that restoration of on-street parking did not have any adverse impact on traffic flow in the city center. Since then, traffic has increased dramatically, and there is now traffic congestion during the peak periods at the westbound approach of the Main and Moody Street intersection, because parking restricts through traffic to one lane in the westbound direction. The Waltham Business Association has expressed its concern that the current on-street parking be maintained; therefore, strategies that will improve traffic flow, reduce traffic delays, and preserve the current parking should be sought.

2.3 TRANSIT-RELATED PROBLEMS

Public transportation plays a major role in the Route 20 corridor, as it serves a substantial portion of the commuter trips in the study area.

In the Boston area, the following bus routes run along Brookline Avenue and have their terminus at Kenmore Square: Route 8 (Harbor Point/UMass-Kenmore Station), Route 8A (Dudley Station-Kenmore Station), and Route 60 (Chestnut Hill-Kenmore Station). Route 57 (Watertown Square-Kenmore Square) is a high-capacity route with Brighton Avenue and Commonwealth Avenue as its most heavily traveled segments. Route 64 (Oak Square-Central Square) buses travel on North Beacon Street in Brighton, and Route 66 (Harvard Square-Dudley Station) buses travel on Brighton Avenue in Brighton.

There are two bus terminals in Watertown, the Watertown Square and Watertown Yard terminals. Route 59 (Dedham Mall-Watertown Square) and Route 71 (Watertown Square-Harvard Station) have their terminal at Watertown Square. The Watertown Yard terminal serves Route 52 and 57 buses, and the express buses (Routes 502 and 504) that travel from Watertown to downtown Boston via the Massachusetts Turnpike. Routes 70 and 70A (Cedarwood Avenue-Central Square, Cambridge) travel along Route 20 in Waltham and Watertown.

The Green Line B light rail transit runs in the median of Commonwealth Avenue between Packard's Corner (Brighton Avenue) and Blandford Street in Boston. The Fitchburg commuter rail line has a station and a park-and-ride lot at Waltham Central Square.

The following sections describe in detail the transit-related problems identified in the corridor. They are grouped by mode and by municipality.

2.3.1 Bus Transit Problems

Access to the Kenmore Square Station Terminal in Boston

The Kenmore Square bus terminal serves Route 57 buses that run along Commonwealth Avenue and Route 8, 60, and 65 buses that run along Brookline Avenue. This terminal is located in the middle of Kenmore Square, and it generates high pedestrian and bus traffic volumes. Bus access to the station terminal needs some improvements, especially from Brookline Avenue. Because the eastbound traffic on Commonwealth Avenue and Brookline Avenue share the same phase (move at the same time), buses coming from Brookline Avenue have to merge and weave through three traffic lanes on Commonwealth Avenue to get into the station terminal (see Figure 2-16). During peak periods, bus drivers find it difficult to enter the terminal because of the high volume of merging traffic.

Separating the Brookline Avenue traffic phase from that of Commonwealth Avenue could increase overall vehicle congestion and delay as a result of the additional phase. A phasing plan that resolves this issue, reduces delays, and provides buses easy access to the terminal is necessary to improve safety and traffic operations at Kenmore Square.

Bus Navigation and Passenger Transfers at Union Square in Brighton

Union Square is the intersection of Cambridge Street, Brighton Avenue, and North Beacon Street in Brighton. It serves as a major transfer point for Route 57, 64, and 66 buses. A navigation problem exists at Union Square for Route 66 bus drivers: difficulty navigating the left-turn maneuver from the southbound approach on Cambridge Street onto Brighton Avenue eastbound (see Figure 2-17).

Another issue is a result of some bus stops having been relocated in connection with the revised intersection layout resulting from the Brighton Avenue Reconstruction Project. In addition, bus drivers still stop at the old bus stops to pick up passengers who use them to avoid walking extra distances. In other words, some of the current bus stops are not facilitating transfer of passengers.

FIGURE 2-16

Bus Access Problem at Kenmore Square Station in Boston

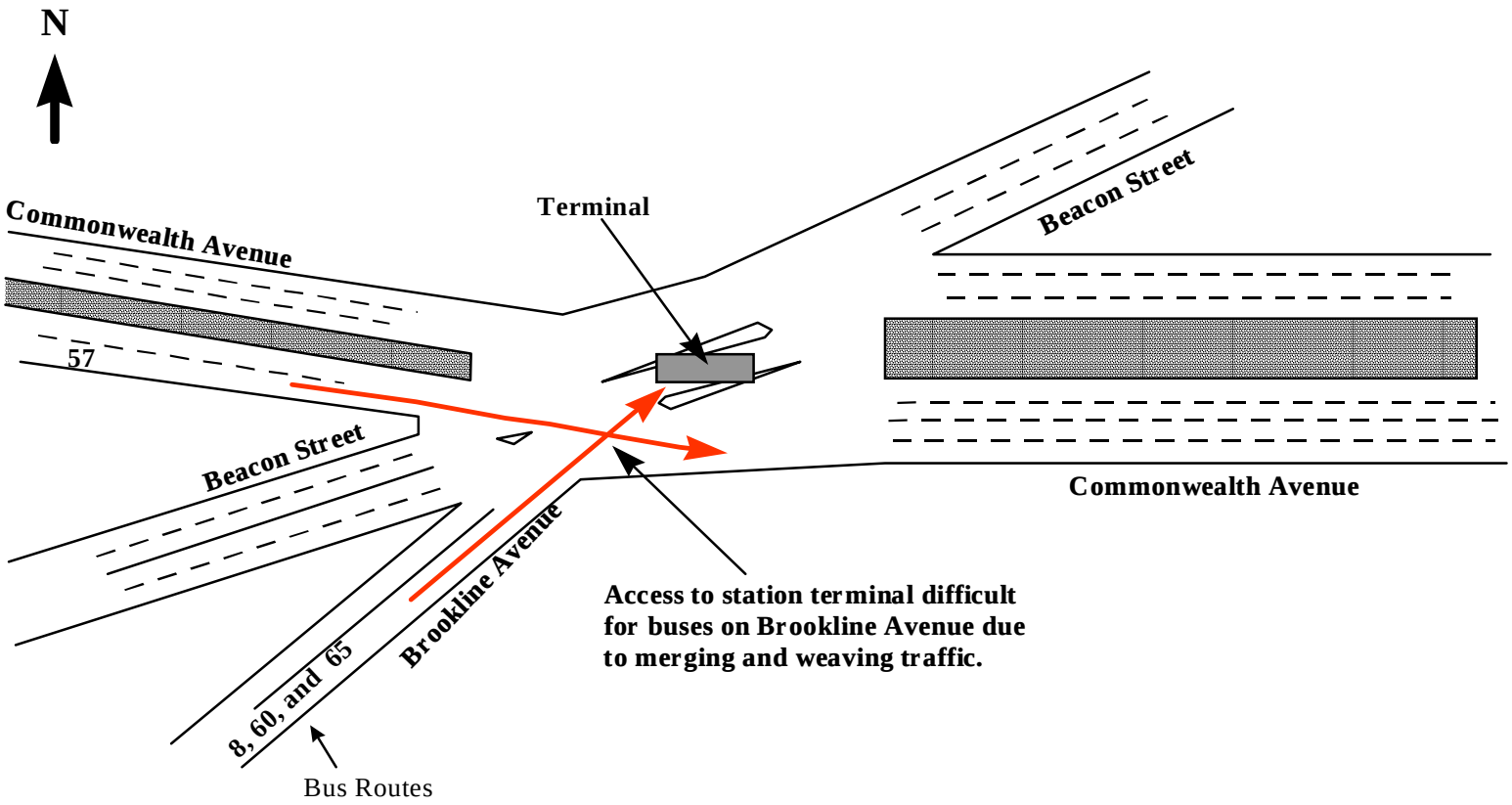
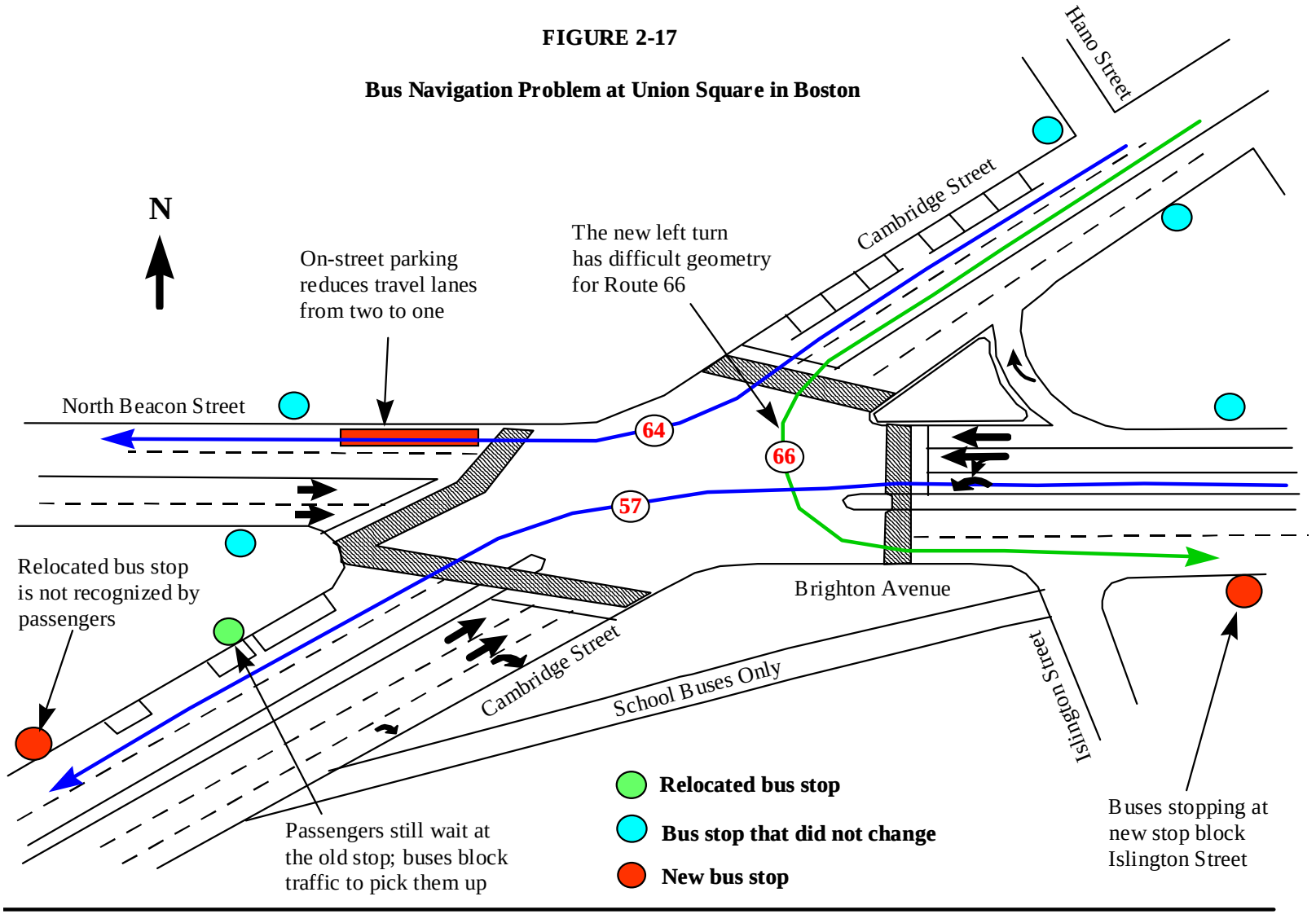


FIGURE 2-17

Bus Navigation Problem at Union Square in Boston



Bus Transfers Between the Watertown Square and Watertown Yard Terminals

The Watertown Square station terminal serves bus Routes 70, 70A, and 71 (Waltham and Watertown to Central Square, Cambridge) and bus Route 59 (Needham Junction-Watertown Square). In close proximity, on Galen Street, is the Watertown Yard terminal. (See Figure 2-18.) This terminal serves bus Routes 57 (Watertown Yard-Kenmore Station), 502 (express, Watertown Yard-Copley Square), and 504 (express, Watertown Yard-Downtown Boston).

Passenger transfer between these two terminals is not easy: passengers have to cross the bridge over the Charles River and pass through two busy intersections. Under normal circumstances this can take about five minutes, making timed transfers difficult in some cases. Figure 2-18 shows the locations of the two terminals, the bus routes, and the walking distance involved.

A bus passenger survey conducted by CTPS for the MBTA included information on transfers between these terminals; see Table 2-9. About 500 passenger transfers take place between the two terminals each day. The MBTA has opened a new 200-space park-and- ride lot adjacent to the Watertown Yard. This provides convenient parking for passengers and reduces parking on residential streets. Presently, at the Watertown Square terminal, there are no parking facilities and there is not enough space to accommodate more buses. Improving the passenger transfer problem by eliminating transfers between the terminals would increase safety, but other issues such as availability of parking and space at both terminals need to be considered to prevent congestion. There is also the issue of additional travel time, which could affect the scheduling of buses.

Bus Schedule Adherence

Traffic signal delays affect the schedule adherence of bus routes along Route 20. Reducing overall trip time and improving schedule reliability and timed transfer call for reductions in mid-block and intersection traffic delay. Two segments of Route 20 are of great concern for MBTA bus operations: (1) Main Street between Watertown and Waltham, for Route 70 and 71 services, and (2) Brighton Avenue and Commonwealth Avenue in Boston extending from Cambridge Street to Kenmore Station, for Route 57 buses. Route 64 buses, which travel along North Beacon Street in Brighton also face signal delays.

The existing cumulative bus passenger hours of delay for Routes 57, 64, and 70 during the peak hours are shown in Table 2-10. These signal delay values are only for those portions of the bus paths that lie along the Route 20 arterial and have traffic signals. Mid-block delays that occur as a result of traffic disruptions such as those related to parking are not included in the signal delay and person-hours of delay. Detailed signal delay information at each intersection faced by the buses is provided in Appendix C of this report.

2.3.2 Green Line B Branch Light Rail Transit (LRT)

Service Quality

In 1994, CTPS conducted for MBTA a systemwide passenger survey.[2] As can be seen in Table 2-11, the most frequent comments received from passengers on the Green Line B Branch were:

1. Requests for more service.
2. Requests for express trains.
3. Complaints about unreliability.
4. Complaints about passenger crowding.

Other frequent comments from passengers on the Green Line B Branch included complaints about slow service and personal safety. The survey revealed that around 95% of the Green Line B customers walk to access the train and about 86% have access times of 0-5 minutes. On the average, 43% of all Green Line B passengers wait less than 5 minutes to board the train, while around 48% wait between 5 and 10 minutes. Data on passenger waiting times, access modes, and access times for the Green Line B Branch are contained in Appendix C of this report.

Passenger Crowding Problem

The average weekday passenger loadings for inbound and outbound trips are shown in Table 2-12 for the peak periods. Currently, in the peak periods, the frequency of service of the Green Line B Branch is five minutes. The minimum service frequency specified by the MBTA service delivery policy for light rail/rapid transit in the peak period is 10 minutes on all portions of all branches.[3]

The proportion of trips with 1.5 or more passengers per seat are given in Table 2-13. It is realized from that table that passenger loading is approaching the MBTA threshold of 2.0 passengers per seat during the peak periods. For a substantial portion of the operating hours, about 29 percent of the trips have at least 1.5 passengers per seat, i.e., at least 50 standees per train.

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[2] *MBTA Systemwide Passenger Survey*: *Green Line*, conducted by the Central Transportation Planning Staff for the Boston Metropolitan Planning Organization, January 16, 1997.

[3] Service Delivery Policy, Massachusetts Bay Transportation Authority, September 1996.

FIGURE 2-18

Bus Transfer Problem Between Watertown Square and Watertown Yard Terminals in Watertown

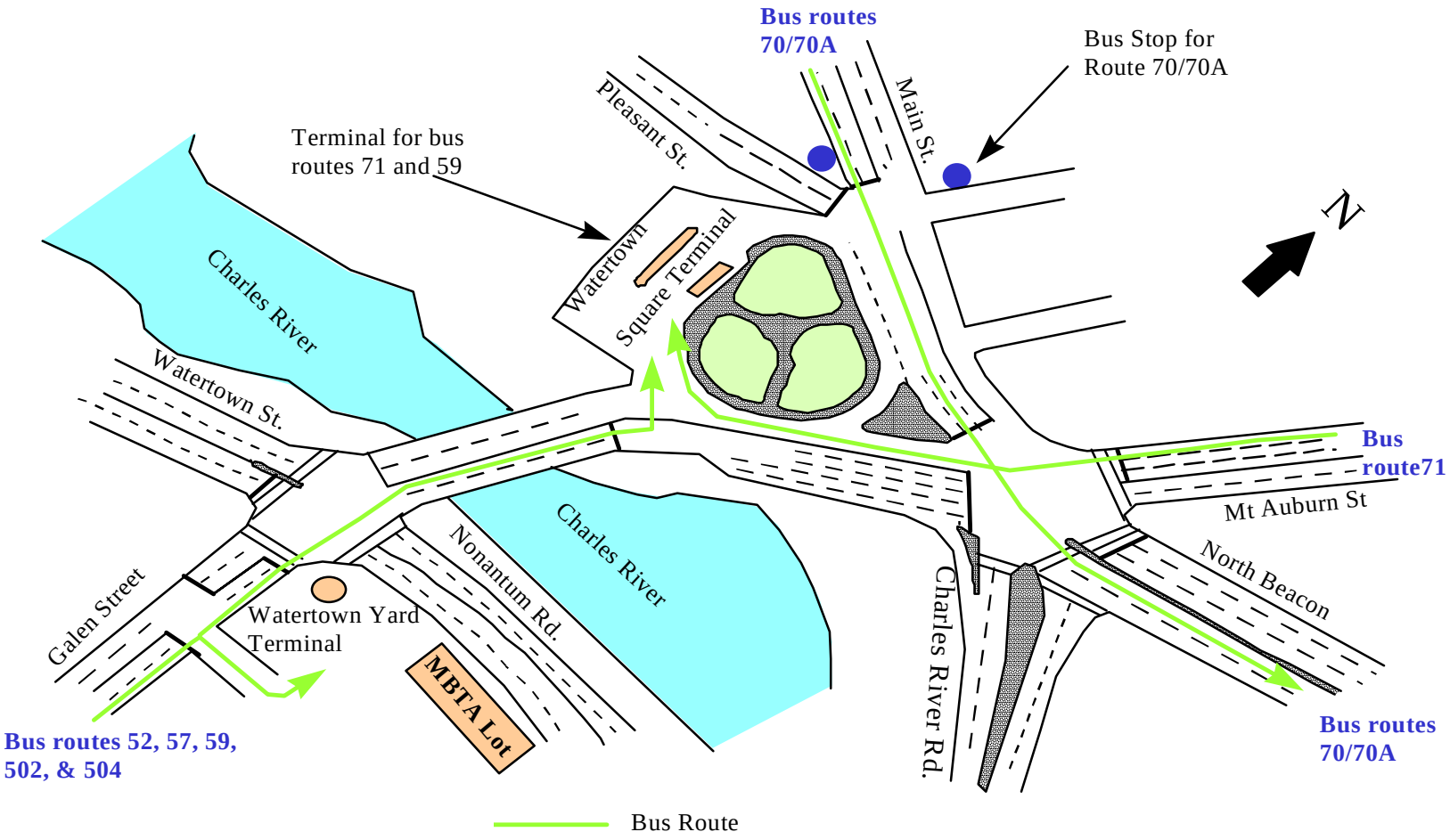


TABLE 2-9

Bus Passenger Transfers at the Watertown Square and Watertown Yard Terminals

		Bus Routes							
	To and From	**70**	**70A**	**71**	**59**	**52**	**57**	**502**	**504**
Bus Routes	**70**	–	0	102	13	0	106	38	42
	70A	0	–	17	8	0	6	6	0
	71	192	0	–	74	23	50	64	64
	59	66	18	81	–	6	36	0	0
	52	19	0	93	0	–	19	19	122
	57	34	61	115	0	0	–	82	101
	502	11	0	7	0	4	28	–	0
	504	54	0	9	0	13	4	0	–

Note: Numbers in the above table are passenger transfers per day.

TABLE 2-10

Cumulative Passenger Hours of Delay for Existing Conditions

		Eastbound		Westbound	
Bus Route	**Peak Hour**	**Average Signal Delay per Trip (minutes)**	**Person-Hours of Delay**	**Average Signal Delay per Trip (minutes)**	**Person-Hours of Delay**
Route 57 Commonwealth Avenue and Brighton Avenue in Brighton and Boston	AM	5.5	40.3	2.1	5.3
	PM	7.6	17.0	3.5	18.1
Route 64 North Beacon Street in Brighton	AM	3.5	3.3	2.0	0.4
	PM	1.3	0.4	2.8	2.3
Route 70 Weston Street and Main Street in Waltham, Main Street in Watertown	AM	9.5	12.0	8.5	8.5
	PM	8.0	8.2	7.6	15.4

Note: These numbers include only those bus paths that lie along the Route 20 arterial

TABLE 2-11
Passenger Survey Responses Regarding Customer Service on the Green Line B Branch (Light Rail Transit)

Service Quality	Mean	Very Poor (%)	Poor (%)	Average (%)	Good (%)	Very Good (%)	Total	Importance*
Station Condition	3.2	3.0	10.5	55.6	24.5	6.4	14,759	344
Station Cleanliness	3.2	3.4	12.7	50.8	27.4	5.7	14,508	450
Parking Availability	2.1	43.1	20.6	26.1	5.7	4.5	7,449	191
Personal Safety	3.5	3.6	7.4	37.6	36.6	14.7	14,818	2,819
Vehicle Security	2.8	15.3	14.3	48.6	16.3	5.5	5,375	124
Cleanliness of Trains	3.2	3.9	16.5	42.8	30.5	6.3	15,400	1,165
Reliability	2.7	17.2	28.4	31.2	17.4	5.8	15,718	5,667
Explanation of Delays	2.3	32.7	26.4	28.1	9.5	3.7	13,830	604
Announcements for Stops	2.7	16.9	24.9	32.8	17.9	7.4	15,661	586
Availability of Seating	2.5	22.8	25.4	33.5	12.7	5.6	15,799	2,211
Frequency of Service	2.8	15.5	22.7	32.9	21.4	7.5	15,876	5,431
Travel time	2.6	21.0	24.0	32.8	16.2	6.1	15,767	4,365

Shaded rows represent poor service quality measure.

* The number of respondents who indicated that this service quality measure was one of the three most important to them. Many respondents checked no measure, while others checked more than three.

TABLE 2-12

Green Line B Branch Passengers per Seat for Peak Period

	Passengers per Seat for Inbound Peak Period			Passengers per Seat for Outbound Peak Period		
Station	**Minimum**	**Average**	**Maximum**	**Minimum**	**Average**	**Maximum**
Blandford Street	0.84	1.19	1.59	0.98	1.21	1.63
BU East	0.84	1.21	1.82	1.11	1.26	1.76
BU Central	0.86	1.24	1.85	1.12	1.37	1.92
BU West	0.84	1.33	2.08	1.11	1.36	1.87
St. Paul Street	0.85	1.33	2.02	1.05	1.31	1.84
Pleasant Street	0.86	1.31	2.00	0.94	1.21	1.67
Babcock Street	0.85	1.28	1.96	0.98	1.08	1.45
Packard’s Corner	0.82	1.23	1.51	0.75	0.94	1.24

TABLE 2-13

Passenger Crowding on the Green Line B Branch (Light Rail Transit)

	Inbound		Outbound			
	Before Noon		Noon-6:00 p.m.		After 6:00 p.m.	
High-Volume Trips	**Percent of Period**	**Number of Trips**	**Percent of Period**	**Number of Trips**	**Percent of Period**	**Number of Trips**
Percent of Trips ≥ 1.50	29	19	23	16	17	9
Percent of Trips ≥ 2.00	5	3	6	4	4	2

On a two-car train, 1.5 passengers per seat means 50 people are standing at the peak load point.

On a two-car train, 2.0 passengers per seat means 100 people are standing at the peak load point.

Green Line B Branch Signal Priority System

Traffic congestion and traffic signals cause significant delays for Green Line transit service in the study area. The Green B Branch passes through 11 signalized intersections over its 1.4- mile stretch along Commonwealth Avenue. These 11 signals have semi-actuated controls that return any unused green time on the cross streets to the arterial (Commonwealth Avenue). To provide more efficient service for the Green Line, a signal priority system was installed to give priority to the trolleys at the intersections.

At the moment, this priority system is inoperative. Most of the equipment has broken down or is missing in the field. The present status of the equipment is documented in Appendix C of this report. Currently, the trolleys have no priority, sharing signal phases with the automobiles on Commonwealth Avenue. This has resulted in poor performance and also longer travel times, making the Green Line B Branch an unattractive mode compared to the automobile. It is estimated to cost $82,000.00 to replace the broken and missing equipment according to an assessment study conducted by LS Transit System.

2.3.3 Park-and-Ride Lots

The MBTA recently opened a new park-and-ride lot with 200 spaces at the Maintenance Yard adjacent to the Watertown Yard. This facility has resolved commuters' need for parking spaces at the Watertown Square and Watertown Yard terminals, thereby eliminating the problem of commuters parking on residential streets in the vicinity of the two terminals.

In Waltham, the parking capacity of the Waltham Central Square station lot is not sufficient for commuters. Presently, the 81 spaces available are fully utilized. In a recent study[4] conducted by CTPS for the MBTA it was indicated that by the year 2000 between 125 and 150 parking spaces will be needed to serve commuter rail riders at this station. There is not enough space to expand the existing lot.

The surrounding lots are, however, underutilized (have usage rates below 50%) because of the walking distances involved (see Figure 2-19). The City of Waltham owns, operates, and maintains the MTBA park-and-ride lot, the Carter Street lot, and the Central Square Parking Deck. Improving parking availability at this station would increase ridership per train at this station. Ridership information for the station is shown in Table 2-14.

[4] Commuter Rail Ridership and Parking Demand Forecasts, CTPS Report, 1996

FIGURE 2-19

Parking Access and Availability at Central Square in Waltham

TABLE 2-14

Peak Period Capacity and Reserve Seating at Waltham Commuter Rail Station

Train Number	Due North Station	Ons	Offs	Passenger Load	Passengers per Seat	Reserve Seating Capacity
404	7:15 a.m.	41	-	348	0.75	117
408	8:00 a.m.	45	3	466	0.84	88
410 Express	8:20 a.m.	50	4	551	0.67	273
412	8:45 a.m.	30	3	348	0.54	291
454	9:19 a.m.	18	-	141	0.30	324
Total, Peak Period		184	10	1854	0.63	1093

2.4 PEDESTRIAN CROSSING AND ACCESS ISSUES

Generally, an agreed-upon definition of a pedestrian is "any person afoot" and may consist of one or a combination of these: the young and the elderly, men and women, the healthy and handicapped, and the utilitarian and the recreational. The land uses along Route 20 generate high volume of pedestrian activity, especially in the city centers and recreational areas. Pedestrians use the crosswalks, sidewalks, shoulders, and the streets to get to their destination or carry out their activities in the presence of moving traffic.

Pedestrian safety was a major concern expressed at the public meetings. Three major locations along Route 20 identified with pedestrian crossing problems are:

1. Kenmore Square in Boston.

2. Commonwealth Avenue in the Boston University area in Boston.

3. The intersection of North Beacon Street and Greenough Boulevard in Watertown.

2.4.1 Pedestrian Crossing at Kenmore Square in Boston

At Kenmore Square, many pedestrians access the MBTA station using the crosswalks (i.e., surface streets). Some cross outside designated crosswalks and against oncoming traffic. Figure 2-20 shows the current crosswalks in the Square along with:

1. The type and condition of the pavement markings.

2. The type of operation, i.e., exclusive pedestrian phase or concurrent pedestrian phase.

3. Crosswalks that need improvements.

4. Areas where crosswalks are needed or should be prohibited.

Besides the surface crosswalks, the MBTA portals provide underpasses that connect both the surface bus terminal and the Green Line subway station to the surface-street sidewalks. The pedestrian crossing volumes for the peak periods and midday at the Square along with the volumes at the MBTA portals are shown in Figure 2-21. Most of the crosswalks are well-marked with bright white paint and operate by pedestrian-actuated push-buttons. The sidewalks provide adequate holding areas for pedestrians using the crosswalks.

As shown in Figure 2-20, there is one location which is heavily used by pedestrians to cross Commonwealth Avenue but which does not have a formalized pedestrian crosswalk. Two other locations where pedestrians cross Commonwealth Avenue to access the MBTA station terminal were found to be unsafe for crossing, as also shown in Figure 2-20. These locations are

presently without crosswalks and should not be formalized. Some crosswalks in the Square need painting to draw the attention of both pedestrians and drivers.

2.4.2 Pedestrian Crossing in the Boston University Area Along Commonwealth Avenue

Boston University student-related activities generate high pedestrian volumes along Commonwealth Avenue from Sherborn Street to Babcock Street. Because the Green Line's B Branch runs in the median of Commonwealth Avenue, passengers always have to cross the streets to board trains or exit from the station platforms. The high volume of traffic on Commonwealth Avenue makes pedestrian crossing difficult. In 1992, the University of Massachusetts-Boston conducted a pedestrian study at the Boston University campus.[5]

Key findings of this study are summarized in Table 2-15 for Commonwealth Avenue and its cross-streets. The study revealed that the main pedestrian problems are:

1. Jaywalking (crossing outside designated crosswalks).

2. Pedestrians crossing when pedestrian light is red or against oncoming traffic.

3. Drivers speeding and failing to yield to pedestrians in crosswalks.

A relative comparison of pedestrian volume at intersections in the BU area is given in Table 2-16. As can be seen, there are high pedestrian traffic volumes throughout the day. Currently, crossing is difficult in the westbound direction because of the three lanes involved. Improvements are needed to facilitate pedestrian crossing along this segment.

2.4.3 Pedestrian Crossing at the North Beacon Street and Greenough Boulevard Intersection in Watertown

This unsignalized T-intersection on North Beacon Street at the Watertown end of the bridge over the Charles River is controlled by the MDC. Because it is located in a park, its cross-street (Greenough Boulevard) serves mostly recreational traffic. There are two main problems facing motorists, bicyclists, and pedestrians at this intersection.

First, drivers on Greenough Boulevard often find it difficult to enter North Beacon Street because of poor sight distance (caused by the arched bridge) and the high traffic volumes on North Beacon Street. Second, pedestrians and bicyclists often have to cross North Beacon Street to access Greenough Boulevard, which is difficult and dangerous for three reasons:

[5] *Boston University Pedestrian Study*, Center for Survey Research, University of Massachusetts-Boston, final report, April 1992.

FIGURE 2-20

Pedestrian Crosswalks at Kenmore Square in Boston

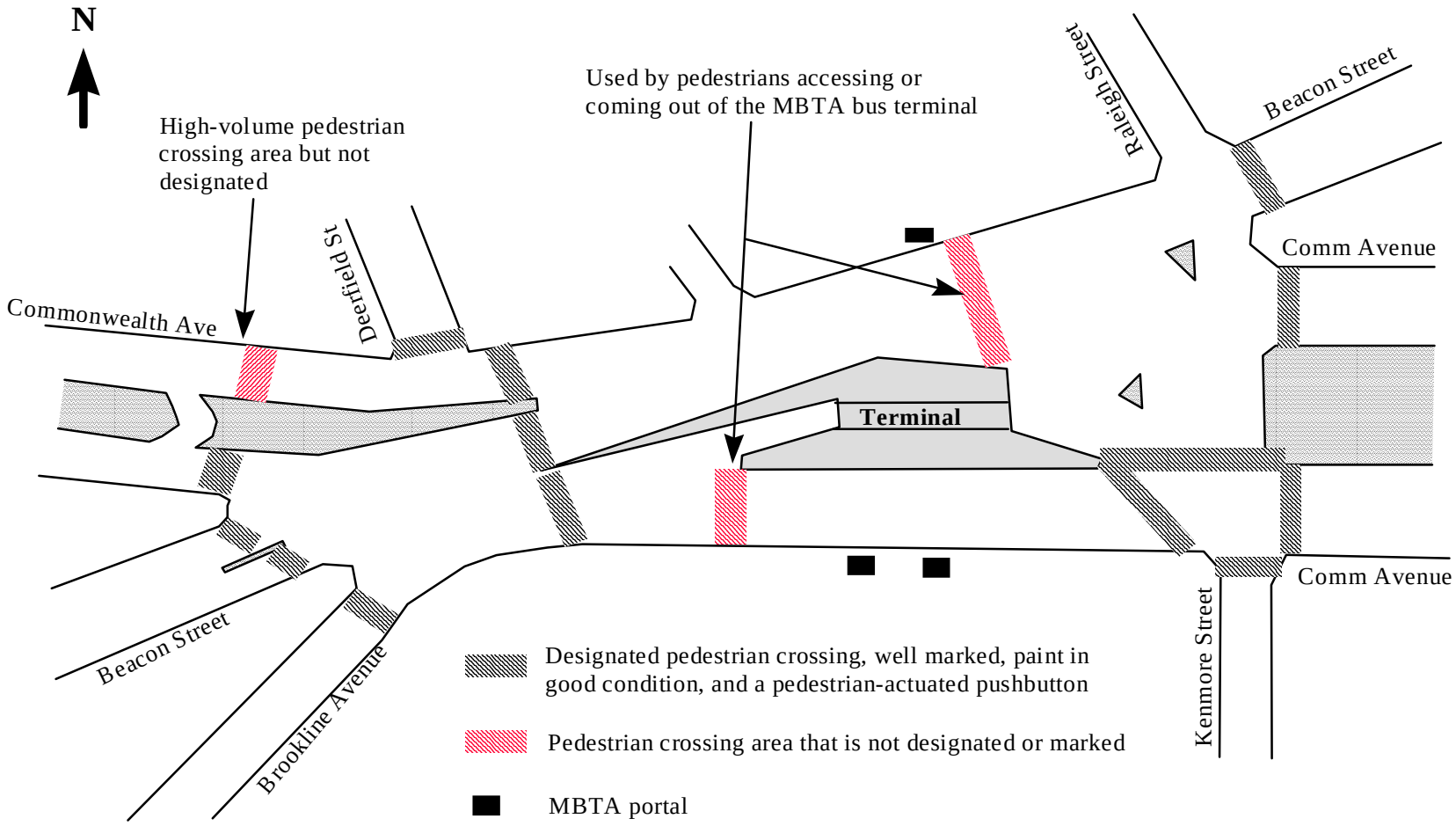
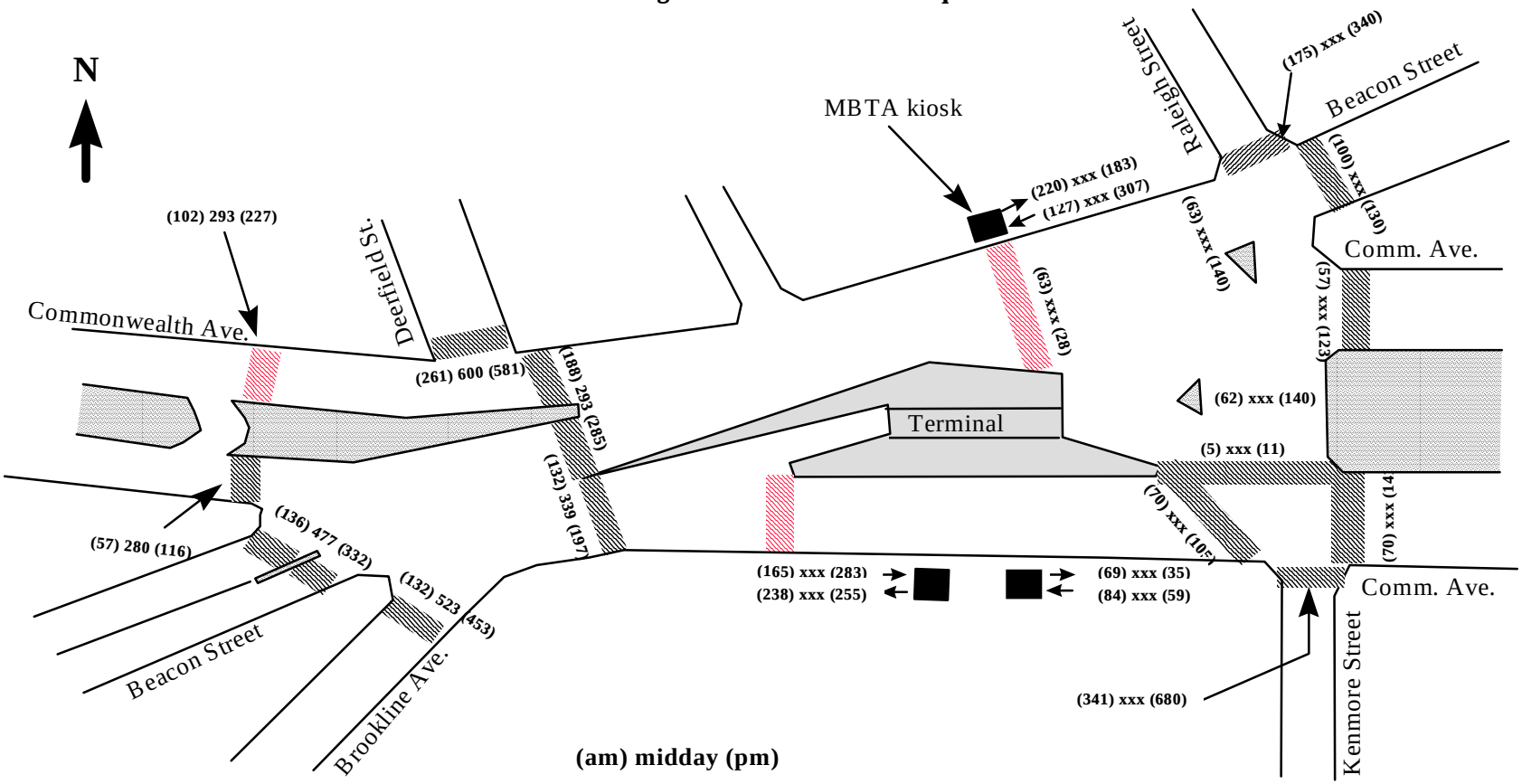


FIGURE 2-21

Pedestrian Crossing Volumes at Kenmore Square in Boston



Source: Howard/Stein-Hudson Associates, Inc.

TABLE 2-15

Pedestrian and Driver Behavior Along Commonwealth Avenue in the BU Area

Street Name	Percent of Pedestrians Jaywalking	Percent of Pedestrians Crossing on "Don't Walk"	Percent of Drivers Yielding to Jaywalkers	Percent of Drivers Yielding to Pedestrians in Cross-walks	Percent of Drivers Yielding to Pedestrians with "Walk"	Percent of Cars Speeding >10 mph over Speed Limit
Commonwealth Ave. (Day-Early Evening)	26.8 (2645)	86.4 (1913)	38.2 (448)	19.6 (989)	69.8 (43)	0.2 (7353)
Commonwealth Ave. Cross-Streets (Day-Early Evening)	30.7 (1065)	17.7 (729)	45.8 (72)	47.1 (119)	68.2 (66)	-
Commonwealth Ave. (Night)	41.4 (628)	79.6 (368)	59.0 (105)	15.1 (159)	10.5 (24)	7.1 (3271)

Note: Numbers in parentheses are counts of observations.

TABLE 2-16

Pedestrian Crossing Volumes by Intersection Along Commonwealth Avenue in the BU Area

Intersection Commonwealth Avenue @:	AM 8:15-9:15 Volume (rank)	12:30-1:30 Volume (rank)	PM 5:00-6:00 Volume (rank)	Totals Volume (rank)
Babcock Street	612 (8)	1116 (6)	1018 (3)	2791 (6)
H. Agganis/Pleasant Street	535 (9)	843 (9)	719 10)	2097 (9)
St. Paul Street	904 (5)	1200 (5)	754 (9)	2858 (5)
Amory Street	436 (10)	691 (10)	794 (8)	1921 (10)
B.U. Bridge	795 (7)	899 (8)	987 (4)	2681 (8)
Carlton Street	811 (6)	954 (7)	983 (5)	2748 (7)
St. Mary's Street	1016 (4)	2524 (2)	2149 (1)	5689 (2)
Cummington Street	1439 (2)	2945 (1)	1798 (2)	6182 (1)
Granby Street	1642 (1)	1717 (3)	940 (6)	4299 (3)
Sherborn/Blandford Street	1404 (3)	1320 (4)	851 (7)	3575 (4)

Source: Bruce Campbell & Associates, Inc.

1. Wide roadway: pedestrians have to cross all four traffic lanes at the same time, as there is no median in the roadway.

2. High traffic volumes on North Beacon Street: pedestrians have to wait a long time before they can get a suitable gap to cross. Part of the reason for this is that there are no signals nearby, so the traffic flow is not interrupted.

3. The arched bridge over the Charles River reduces sight distances for both pedestrians and drivers, making it difficult to determine when it is safe to cross North Beacon Street.

The current crosswalks are not functioning well, as drivers do not yield to pedestrians. Improvements are needed to facilitate crossings at this intersection as well as to connect the bike path and sidewalk along North Beacon Street.

2.5 BICYCLE TRAFFIC AND SAFETY ISSUES

2.5.1 Bicycle Storage Facilities

Bicycle transportation is not well integrated in the Route 20 corridor to take advantage of the public transportation system. There are no storage facilities for bicycles at the MBTA park-and-ride lot in Waltham Central Square or the Watertown Yard park-and-ride lot in Watertown. Bicycle storage facilities are needed at major public transportation terminals and transfer points to encourage bicyclists to use transit services. Possible locations are Watertown Square, Union Square, and Kenmore Square.

2.5.2 Improved Signal Timings

Clearance time (yellow plus all-red time) at signalized intersections is designed for vehicular traffic: the average speed and length of vehicles passing through the intersection. At large or staggered intersections with high bicycle traffic volumes, clearance times designed for motor vehicles may not be enough for bicyclists, as they travel at lower speeds.

The intersections of Main Street with Barbara/Gore and Warren Streets in Waltham is a typical example. Because these intersections are staggered but close to each other (approximately 100 feet apart), bicyclists who enter at the on set of the yellow light can not cross both intersections before the all-red indication is terminated. Improvements are needed in clearance timing in order for bicyclists going in either the westbound or the eastbound direction to be able to cross both intersections safely and without running red lights.

2.5.3 Integration of Bike Paths and Lanes in Waltham and Watertown

Route 20 in the city centers of Waltham and Watertown has metered on-street parking and exclusive left-turn bays that limit straight-through traffic to one lane at many locations. The narrow traffic lanes affect bicycle traffic, and motorists are unwilling to overtake bicyclists for safety reasons.

To accommodate bike traffic, lightly traveled streets parallel to Route 20 may be more attractive. Such streets need to be examined further for the feasibility of adding a bike lane to connect the Charles River bike path and to provide access to the park-and-ride lots in the two communities (see Figure 2-22). Improved signing is needed along Route 20 to inform motorists regarding sharing the road with bicyclists.

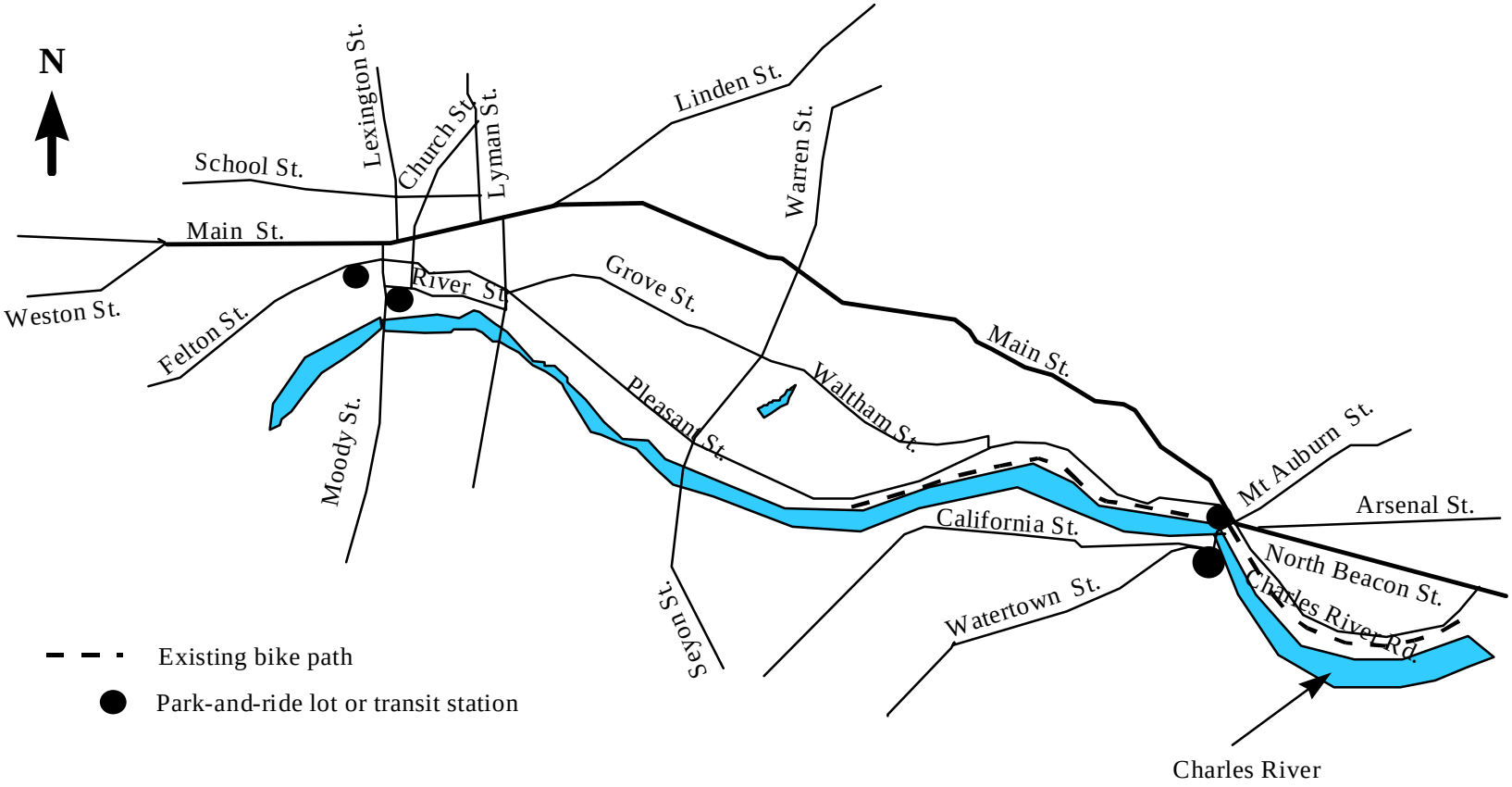
2.5.4 Allocation of Road Space for Parking and Bike Use

Charles River Road between Watertown Square and North Beacon Street is a four-lane arterial controlled by the MDC. Currently, the poor road surface condition of the portion of North Beacon Street in this area forces drivers to use Charles River Road. This problem will be addressed by the North Beacon Street Reconstruction project (currently in progress). Despite this diversion of traffic, Charles River Road has very low traffic volumes (204 vehicles per hour [vph] and 213 vph for the a.m. and p.m. peak hours, respectively). Because North Beacon Street connects both ends of it and provides a shorter path, Charles River Road can be expected to have even lower traffic volumes after the reconstruction of North Beacon Street is completed.

Charles River Road borders park lands for its entire length on one side; on the other side are residential buildings and the Perkins Institute for the Blind. There is a bike path along the river side of the road which is used heavily by both pedestrians and bicyclists. At our public meetings, citizens complained of vehicular speeding on North Beacon Street and Charles River Road and suggested reconfiguration of Charles River Road to serve mostly parking and recreational use.

FIGURE 2-22

Integration of Bike Transportation in Watertown and Waltham



3. PROPOSED STRATEGIES TO ADDRESS PROBLEMS IDENTIFIED IN WALTHAM

In Chapter 2, we described the transportation problems identified within the Route 20 corridor for all three communities (Waltham, Watertown, and Boston). This chapter contains the improvements recommended to address those problems identified in Waltham. Improvements recommended for addressing the problems identified in Watertown and Boston are described in Chapters 4 and 5, respectively. As in the chapter on identified problems, our recommended improvements are grouped by mode of transportation: highway, transit, and non-motorized means such as bicycling and walking.

3.1 STRATEGIES TO ADDRESS ARTERIAL AND INTERSECTION-RELATED PROBLEMS

It is recommended that all the signalized intersections along Route 20 (Main Street and Weston Street) in Waltham be retimed and coordinated. By coordinating the signals, traffic flow would be improved and delays reduced to acceptable levels. Also, improved signal indications and phasing patterns are recommended at certain intersections to enhance motorists' understanding, increase safety, and move traffic more efficiently. In addition, this study is proposing lane-use pavement markings and lane-use control signs to resolve the issue of inconsistent lane assignments. The recommended improvements preserve the existing on-street parking stalls along Main Street.

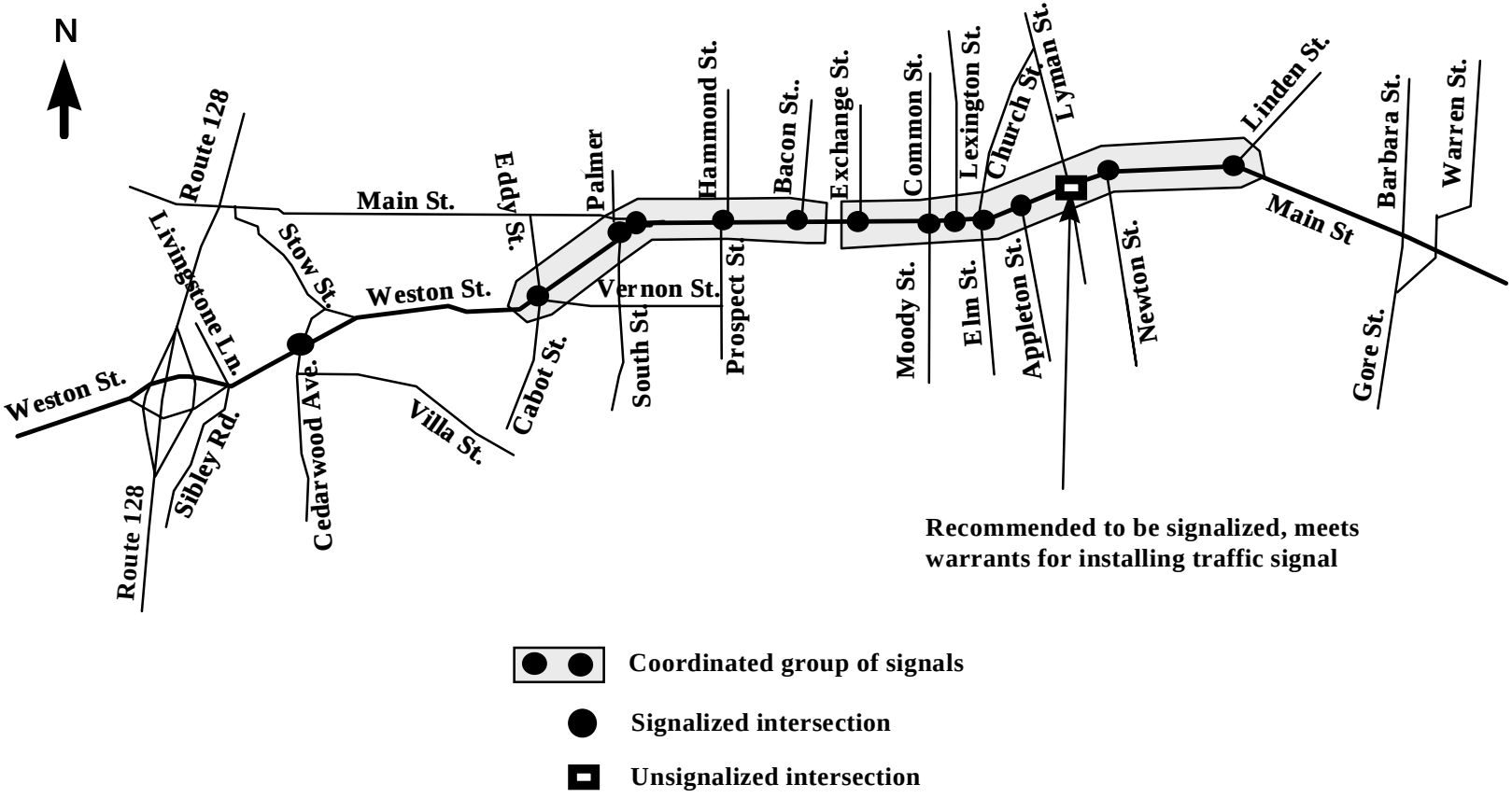
3.1.1 Strategies to Reduce Intersection Traffic Delays

All the signalized intersections along Route 20 in Waltham are divided into two subsystems for operational purposes. Subsystem 1 comprises all the signalized intersections along Main Street from Linden Street (Route 60) to Exchange Street. Subsystem 2 includes all the signalized intersections on Route 20 from Main Street at Bacon Street to Weston Street at Eddy Street (see Figure 3-1). In both subsystems, the signalized intersections have detectors to sense traffic and controllers with the capabilities to operate an actuated-coordinated system.

Presently, the levels of service (LOS) at many of the intersections are unacceptable (LOS E or LOS F during the peak periods), as documented in Chapter 2. Traffic queues spill over from one intersection to another. Furthermore, in Subsystem 1, there is one unsignalized intersection that experiences significant delays on the side streets during the peak periods (Main Street at Lyman and Heard streets).

FIGURE 3-1

Retimed and Coordinated Traffic Signals in Waltham



The City of Waltham has jurisdiction over the traffic signals in both subsystems. The traffic signal at Weston Street and Cedarwood Avenue/Tavern Road is controlled by MassHighway. Table 3-1 shows the type of operation and subsystem groupings for the traffic signals in Waltham. The following sections describe in detail the proposed improvements:

Provide Actuated-Coordinated System for Subsystems 1 and 2

To improve traffic flow and reduce delays, we recommend that the traffic signals in both subsystems along Route 20 arterial be coordinated. Under this strategy, the present subsystem groupings along Main Street will be preserved along with the existing lane assignments and on-street parking. Because the signals are closely spaced in the city center, it is necessary to coordinate their green times so that vehicles move efficiently through the set of signals (a subsystem). Coordinated signals have the benefit of improving service through the reduction of stops and delay for the main street. Another benefit of coordination is that vehicles can be moved at a preferred speed and sent through successive signals in platoons to reduce the number of stops, hence reducing the storage requirements on short blocks with heavy flows and limited space for storage.

PASSER II-90 signal progression software was used to evaluate progression along the two subsystems, using the existing traffic volumes and lane assignments. The resulting intersection approach delays for both subsystems during peak hours are shown in Tables 3-2 and 3-3. It is easily seen from the tables that traffic flow can greatly be improved by coordinating the signals. Detailed outputs such as the common cycle length, offsets, phase and interval timings, pin settings, and lane-group delays are included in Appendix D of this report.

Among the factors that can lessen the benefits from coordination is the existence of substantial side street friction, including parking, loading, double-parking, and multiple driveways. Heavy left-turn volumes can also affect coordination by destroying the platoons. Some enforcement (police assistance) may be required to minimize their effect in the city center.

Retime the Traffic Signal at Weston Street and Cedarwood Avenue/Tavern Road Intersection

We recommend changes in the signal timing and phasing to improve traffic operations and safety at this intersection. With optimized cycle times and phases, peak period traffic delays can be reduced to acceptable levels, including delays for the Weston Street eastbound traffic, by reducing the existing cycle length from 100 seconds to an optimum cycle length of 70 seconds. No changes are recommended in existing lane configurations. With these improvements, all the approaches would operate at LOS C or better, except for the eastbound approach, which would operate at LOS D during the morning peak. The safety problem at this intersection is addressed later on in this chapter.

TABLE 3-1

Mode of Operation and System Grouping for Signalized Intersections Along Route 20 in Waltham

Intersection	Mode of Operation	Grouping
1. Main Street @ Warren St./Gore St.	Semi-Actuated	None
2. Main Street @ Barbara St./Gore St.	Semi-Actuated	None
3. Main Street @ Linden Street	Semi-Actuated	Subsystem 1
4. Main Street @ Newton Street	Semi-Actuated	Subsystem 1
5. Main Street @ Appleton Street	Semi-Actuated	Subsystem 1
6. Main Street @ Elm St./Church St.	Fully Actuated	Subsystem 1
7. Main Street @ Lexington Street	Semi-Actuated	Subsystem 1
8. Main Street @ Moody Street	Fully Actuated	Subsystem 1
9. Main Street @ Exchange Street	Semi-Actuated	Subsystem 1
10. Main Street @ Bacon Street	Semi-Actuated	Subsystem 2
11. Main Street @ Hammond Street	Semi-Actuated	Subsystem 2
12. Main Street @ South Street	Semi-Actuated	Subsystem 2
13. Weston Street @ Eddy Street	Semi-Actuated	Subsystem 2
14. Weston Street @ Cedarwood Avenue	Semi Actuated	None

TABLE 3-2

Approach Delays and Levels of Service Estimated to Result from Retiming and Coordinating Traffic Signals Along Route 20 in Waltham (Subsystem 1)

Subsystem 1		Approach Delay and Level of Service (seconds per vehicle)			
Intersection	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
Main Street @ Linden Street and Ellison Park	AM	16 (B)	28 (D)	_	31 (D)
	PM	8 (B)	19 (C)	_	25 (C)
Main Street @ Newton Street	AM	24 (C)	16 (C)	37 (D)	_
	PM	26 (D)	13 (C)	33 (D)	_
Main Street @ Lyman Street and Heard Street	AM	6 (B)	16 (C)	17 (C)	21 (C)
	PM	6 (B)	14 (B)	18 (C)	23 (C)
Main Street @ Appleton Street	AM	4 (A)	1 (A)	27 (D)	_
	PM	4 (B)	1 (A)	29 (D)	_
Main Street @ Elm Street and Church Street	AM	6 (B)	5 (A)	34 (D)	_
	PM	4 (A)	3 (A)	38 (D)	_
Main Street @ Lexington Street	AM	2 (A)	1 (A)	_	25 (C)
	PM	3 (A)	2 (A)	_	29 (D)
Main Street @ Moody Street and Common Street	AM	20 (C)	9 (C)	26 (D)	_
	PM	19 (C)	10 (B)	25 (C)	_
Main Street @ Exchange Street	AM	2 (A)	3 (A)	26 (D)	30 (D)
	PM	3 (A)	3 (A)	28 (D)	27 (D)

1. For coordination purposes, the common cycle lengths for the a.m. and p.m. peaks are 100 and 110 seconds, respectively.

2. Main Street at Lyman/Heard streets was not included in the signal coordination because it is currently unsignalized .

3. See Appendix D for more details on the analysis.

TABLE 3-3

Approach Delays and Levels of Service Estimated to Result from Retiming and Coordinating Traffic Signals Along Route 20 in Waltham (Subsystem 2)

Subsystem 2		Approach Delay and Level of Service (seconds per vehicle)			
Intersection	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
Main Street @ Bacon Street	AM	13 (B)	13 (B)	_	25 (C)
	PM	23 (C)	19 (C)	_	27 (D)
Main Street @ Hammond St. and Prospect St.	AM	9 (B)	12 (B)	26 (D)	21 (C)
	PM	10 (B)	16 (C)	* (F)	24 (C)
Main Street @ South Street and Route 117	AM	28 (D)	41 (E)	51 (E)	38 (D)
	PM	31 (D)	50 (E)	35 (D)	35 (D)
Weston Street @ Eddy Street/Cabot Street	AM	10 (B)	7 (B)	25 (C)	41 (E)
	PM	11 (B)	8 (B)	32 (D)	26 (D)
Weston Street @ Cedarwood Avenue/Tavern Road	AM	30 (D)	9 (B)	13 (C)	13 (B)
	PM	10 (B)	6 (B)	13 (B)	15 (C)

1. The Weston Street/Cedarwood Avenue/Tavern Road traffic signal is not included in the signal coordination because it is not part of Subsystem 2.

Install Traffic Signal at the Intersection of Main Street and Lyman Street

This unsignalized intersection presently experiences excessive delays at the side streets. Because the side streets have one lane in each direction, it is difficult to turn left or right from this intersection. A traffic signal warrant analysis indicates that this intersection satisfies the following signal warrants specified in the Manual on Uniform Traffic Control Devices (MUTCD)[6]: Warrant 1 - Minimum Vehicular Volume, Warrant 2 - Interruption of Continuous Flow, Warrant 9 - Four-Hour Volumes, Warrant 10 - Peak Hour Delay, and Warrant 11 - Peak Hour Volume. Based on the warrants analysis indicated in Table 3-4, the following improvements are proposed at this intersection to facilitate traffic flow.

- *Install Traffic Signal and Provide a Shared Through-Plus-Left-Turn Lane at the Main Street Eastbound Approach*

  To reduce the excessive traffic delays at the cross streets (Lyman Street and Heard Street), we are proposing that this intersection be signalized, interconnected and coordinated, and included in Subsystem 1 of the Waltham traffic signal system groupings. Both Main Street and the cross streets (Lyman and Heard streets) will operate at acceptable levels of service (i.e., LOS D or better) when signalized (see Table 3-2).

  A shared through-plus-left-turn lane should be provided for the Main Street eastbound traffic and a leading protected-permitted phase plan implemented to facilitate traffic operations. A permitted phase plan for side streets is enough as there is not much traffic on Heard Street. A schematic layout of the proposed lane configuration and phasing pattern is shown in Figure 3-2.

3.1.2 Strategies to Resolve Inconsistent Lane Assignment in Waltham

Inconsistent lane assignments and lane change problems are documented in Chapter 2 of this report. The main areas of concern are the entrapments caused by the lane changes at the following locations:

1. The segment of Main Street between Lexington Street and Elm Street.
2. The westbound approach of Main Street at the intersection with Moody Street/Common Street.
3. Both approaches on Main Street at the intersection with Bacon Street.
4. The westbound approach of Main Street at the intersection with Fiske Street.
5. The eastbound approach of Weston Street at the intersection with Stow Street.

[6] *Manual on Uniform Traffic Control Devices for Streets and Highways*, U.S. Department of Transportation, Federal Highway Administration, 1988 edition.

TABLE 3-4

Traffic Signal Warrant Analysis for Main Street and Lyman Street/Heard Street

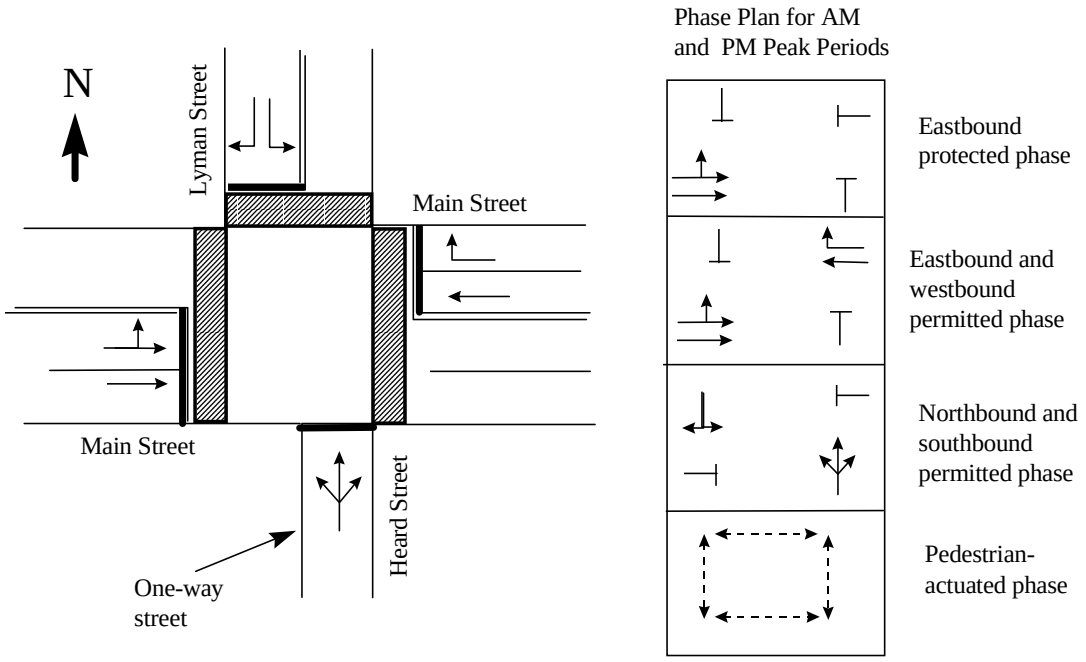
MUTCD Traffic Signal Warrants 1, 2, 8, 9, 10, and 11						
Time	Main Street Total, Both Approaches (Two Lanes)	Side Street High-Volume Approach (One Lane)	Warrant #1	Warrant #2	Warrant #8	
					1(80%)	2(80%)
7-8 a.m.	1634	263	Yes	Yes	Yes	Yes
8-9 a.m.	1974	191	Yes	Yes	Yes	Yes
12-1 p.m.	1531	191	Yes	Yes	Yes	Yes
1-2 p.m.	1467	193	Yes	Yes	Yes	Yes
2-3 p.m.	1493	233	Yes	Yes	Yes	Yes
3-4 p.m.	1713	179	Yes	Yes	Yes	Yes
4-5 p.m.	1919	213	Yes	Yes	Yes	Yes
5-6 p.m.	2021	224	Yes	Yes	Yes	Yes
Warrants requirements			600/150	900/75	480/120	720/60
Hours warrant met			8	8	8	8
Warrant Satisfied			Yes	Yes	Yes	Yes

Warrant #9 (Four-Hour Volumes) is satisfied
Warrant #10 (Peak Hour Delay) is satisfied
Warrant #11 (Peak Hour Volume) is satisfied

See Appendix D for more details on the warrant analysis

FIGURE 3-2

Proposed Improvements at the Intersection of Main Street and Lyman/Heard Streets in Waltham



Field reconnaissance indicated one primary obstacle, on-street parking, to the provision of two continuous straight-through lanes at all of the locations indicated above. On-street parking in the city center of Waltham has reduced the pavement width available, making it impossible to provide two 11-foot lanes in both directions that conform to MassHighway standards. Even if the turn bays are converted to optional movement lanes (left-turn-plus-through-traffic lanes or through-plus-right-turn-traffic lanes), there is no space at the outbound approach to receive two lanes of traffic at these locations.

Considering the importance of on-street parking to businesses in the city center, strategies that will retain on-street parking and help improve traffic flow are required. In line with these objectives, we recommend improvements at each of the locations to give drivers adequate warning and inform them of the lane assignments ahead. The recommended measures are described below.

Proposed Improvements to Address the Inconsistent Lane Assignment at Main Street and Elm/Church Streets

- *Install Lane-Use Arrow Pavement Markings*

  Lane-use arrow pavement markings should be installed to convey guidance and designate mandatory turn lanes at the eastbound approach of Main Street (see Figure 3-3). The pavement markings should be repeated in advance as necessary to prevent entrapment and help motorists to select the appropriate lanes. The markings should conform with the MUTCD guidelines.

- *Install Overhead Lane-Use Control Signs*

  In addition to pavement markings, overhead lane-use control signs as shown in Figure 3-3 should be installed. The lane-use control signs are used here to direct drivers in advance into certain lanes in order to turn. Overhead mounting is proposed for the optional movement sign R3-6 (see MUTCD) because it can be placed directly over the lane to which it applies, adjacent to the signal faces (see Figure 3-3). The mandatory movement sign "RIGHT LANE MUST TURN RIGHT" (R3-7) is to be post-mounted at the intersection, as shown in Figure 3-3, and a second one placed at an adequate distance in advance of the intersection so that motorists can select the appropriate lane before reaching at any queue of waiting vehicles.

- *Provide Five-Lense Cluster Signal Face for the Shared Lanes*

  Provide a five-lense cluster signal face for the shared through-plus-left-turn traffic on both approaches of Main Street, to communicate effectively, the protected-permitted phasing to motorists (see Figure 3-3).

Strategies to Address the Lane-Changing Problems in Waltham

At the remaining four locations listed under subsection 3.1.2, we recommend lane-use pavement markings to clearly show the lane assignments. In addition we recommend the installation of overhead lane-use signs (R3-6) directly over the left-turn lanes to inform drivers and direct them into the left-turn lanes. For the right-turn-only lanes we are suggesting that post-mounted lane-use sign "RIGHT LANE MUST TURN RIGHT" (R3-7) be installed at each intersection and a second one at an adequate distance in advance of the intersection so that drivers can select the appropriate lane before reaching any queue of waiting vehicles. The appropriate types of measures for each of the four remaining locations are summarized in Table 3-5.

FIGURE 3-3

Proposed Improvements to Address Inconsistent Lane Assignment at Main Street and Elm Street/Church Street in Waltham

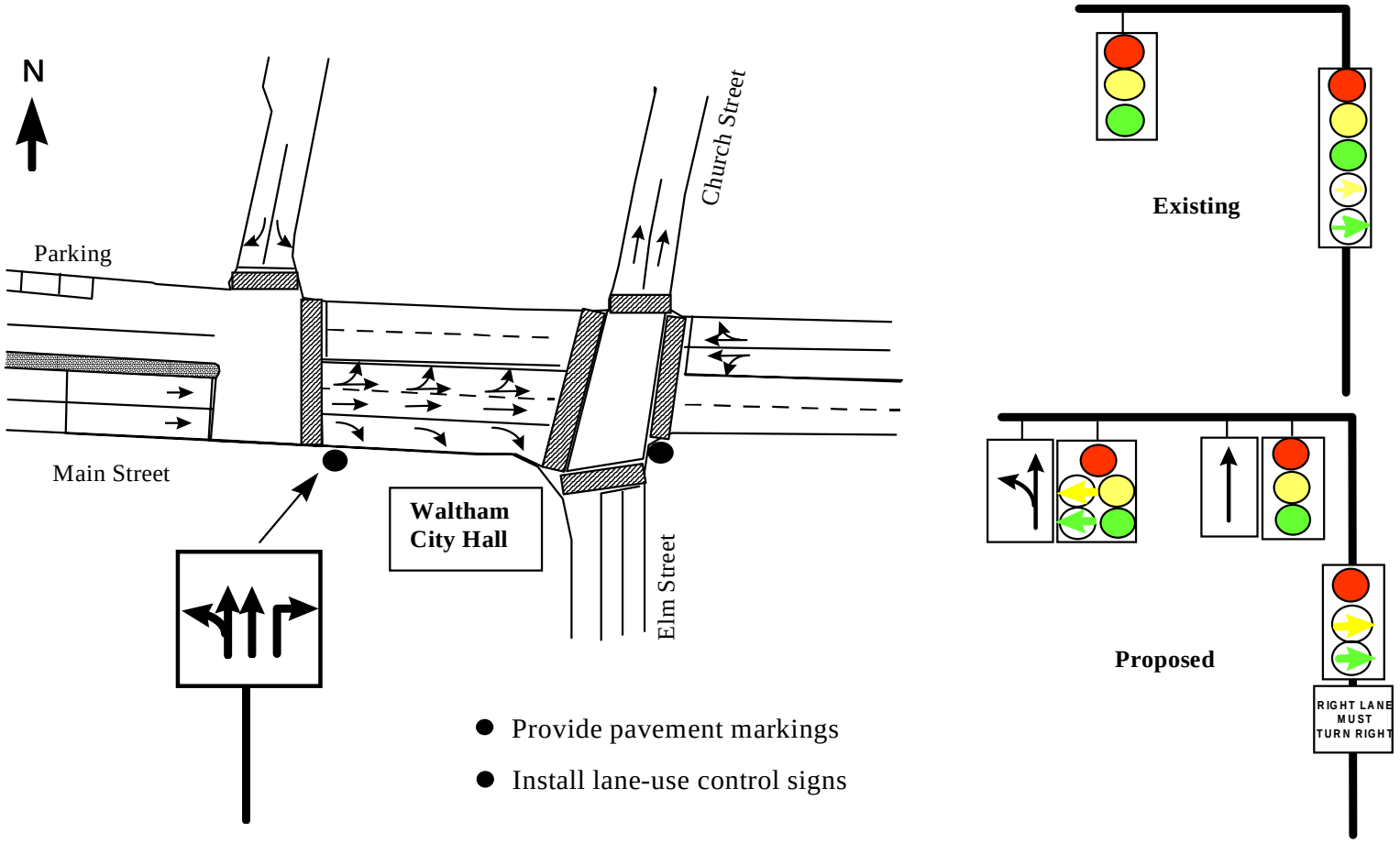


TABLE 3-5

Proposed Strategies to Prevent Entrapment in Turn-Only Bays in Waltham

Intersection	Lane-Use Arrow Pavement Markings	Overhead Lane-Use Signs for Left-Turn Bays	Post-Mounted Lane-Use Signs for Right Turns
Main Street at Moody and Common streets	Required at the westbound approach on Main Street for the through traffic lane	Installed	Not Needed
Main Street at Bacon Street	Required at the eastbound approach on Main Street for the through traffic lane	Installed	Not Needed
Main Street at Fiske Street	Required at the westbound approach on Main Street for the through traffic lane	Installed	Not needed
Weston Street at Stow Street	Required at the eastbound approach on Weston Street for the through traffic lane	Installed	Not Needed

3.1.3 Strategies to Improve Traffic Safety in Waltham

Traffic signal indications at most of the intersections along Main Street in Waltham are well understood by motorists and comply with the MUTCD. Two locations in Waltham where the signal indications are confusing to motorists and create safety problems are: (1) the Main Street eastbound approach at the intersection with Linden Street, and (2) the Weston Street westbound approach at the intersection with Cedarwood Avenue/Tavern Road.

Presently, at Main Street and Linden Street, when the eastbound straight-through green arrow indications come on, they are always accompanied by a circular red indication. These two indications confuse motorists, as they do not know whether to proceed or stop. At the intersection of Weston Street and Cedarwood Avenue/Tavern Road, left turns are prohibited from the Weston Street westbound approach. However, drivers ignore the auxiliary left-turn-prohibition sign, thinking the circular green indications shown to them allow this maneuver.

Two other safety issues identified in Waltham involve: (1) traffic operations and safety at the Banks Square intersection (Main Street/Weston Street/Route 117/South Street) and (2) access from Livingstone Lane and Sibley Road onto Weston Street. At Banks Square, westbound vehicles on Main Street turning left onto South Street create a safety problem for Main Street traffic proceeding west onto Weston Street. This problem arises when the westbound through traffic on Weston Street which is blocked/trapped by left-turning vehicles (due to the permitted-left-turn phasing) decide to pull out into the right lane to proceed through the intersection. This maneuver causes conflicts with the oncoming through traffic and, in some cases, accidents.

Detailed descriptions of these safety problems are provided in Chapter 2 in the section on intersection safety problems. We have identified several strategies for resolving the confusing signal indications and improving traffic operations and safety at these locations. The following subsections describe our recommendations.

Addressing the Signal Indication Problem at Main Street and Linden Street

- *Install a Separate Signal for Left Turns*

  A post-mounted left-turn signal should be installed in the median for the exclusive use of Main Street eastbound left-turning vehicles, as shown in Figure 3-4. This left-turn signal should have three lenses in the signal face to give the following indications: RED ARROW, YELLOW ARROW, and GREEN ARROW. Such indications would provide protected left-turn phasing for a separately controlled left-turn lane. In addition, an auxiliary sign, "LEFT TURN SIGNAL" (R10-10), should be mounted adjacent to the signal face to which it applies, for clarity and to reinforce compliance (see Figure 3-4).

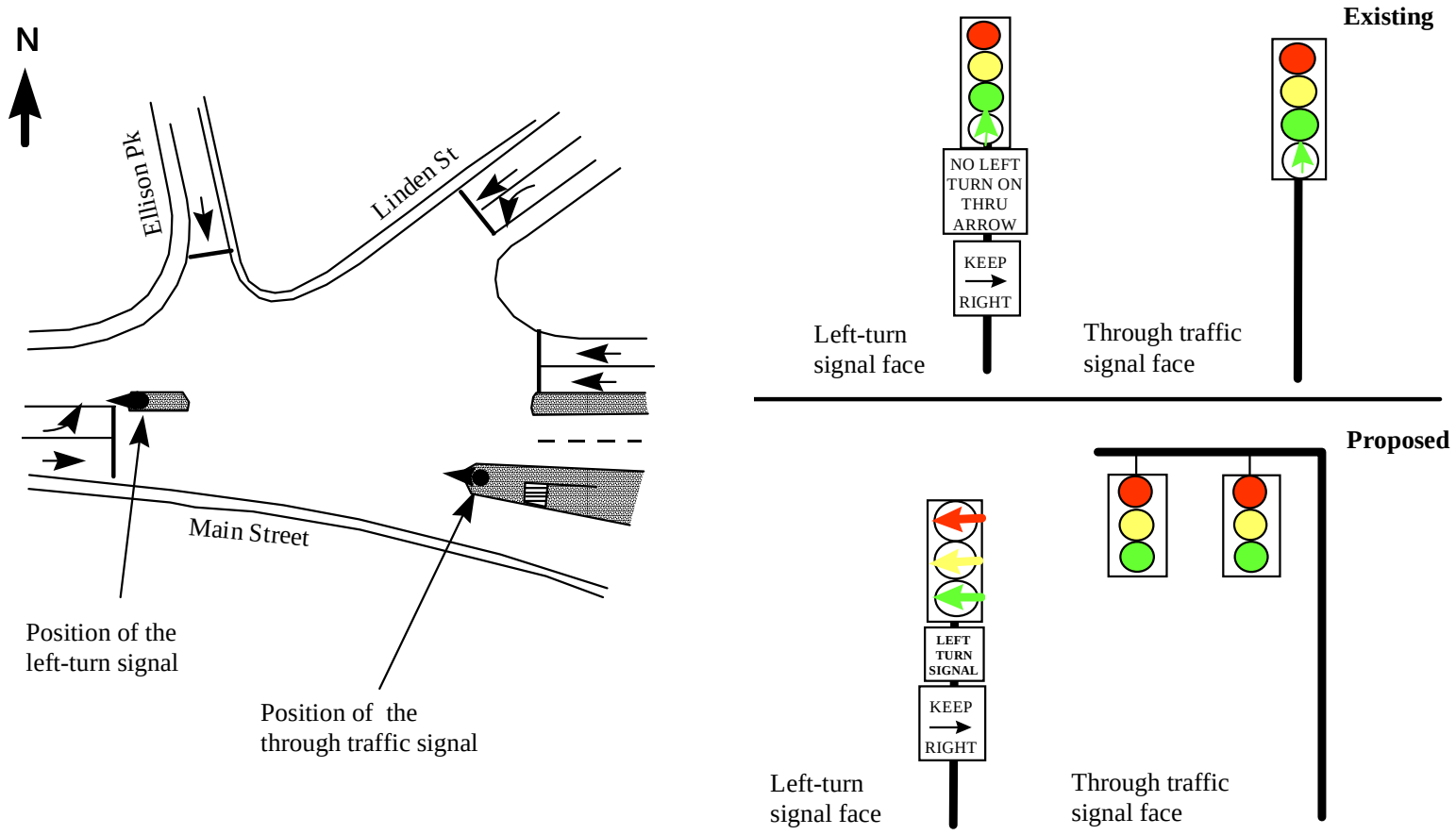
- *Install a Separate Signal for Straight-Through Traffic*

  A separate overhead or mast-mounted signal should be installed at the location shown in Figure 3-4 for the exclusive use of the Main Street eastbound straight-through traffic. This signal should have three lenses in the signal face to show these indications: CIRCULAR RED, CIRCULAR YELLOW, and CIRCULAR GREEN. We recommend an overhead signal because it is more visible to motorists and aesthetically more pleasing.

  The provision of separate signals for both left turns and straight-through traffic would clarify and enhance motorists' understanding of signal indications. It would eliminate the need to show simultaneously in the same signal face a CIRCULAR RED and GREEN ARROW indication.

FIGURE 3-4

Proposed Improvements to Address the Eastbound Signal Indication Problem at Main Street and Linden Street in Waltham



Addressing the Signal Indication Problem at Weston Street and Cedarwood Avenue

As explained earlier, the circular green signal indication shown at this intersection to motorists at the Weston Street westbound approach can lead them to think that they can turn left from that approach. To prevent motorists from making this maneuver, we are recommending changes in the signal indications. These changes would increase safety and efficiency at this intersection.

We recommend replacing the current CIRCULAR GREEN indications shown to motorists at the Weston Street westbound approach with straight-through GREEN ARROW indications (allowing only through movements), as shown in Figure 3-5. The existing left-turn-prohibition sign (R3-2) placed adjacent to the signal face to prohibit left turns should be retained. Provision of straight-through GREEN ARROW indications will help prevent illegal left-turn maneuvers from this approach.

MassHighway currently controls this signalized intersection and has addressed this problem according to our recommendations. Our recommendation for reducing traffic delays at this intersection is described above in section 3.1.1.

Improving Safety and Traffic Operations at Banks Square Intersection in Waltham

This intersection has both safety and traffic delay problems. The entrapment problem facing westbound traffic from Main Street getting onto Weston Street at this intersection is caused by the signal phasing sequence. In a permitted-protected phasing, as designed presently, the westbound left turns from Main Street yield to Weston Street eastbound traffic, causing entrapment.

We recommend that a protected phase be provided for the westbound left turn from Main Street. This strategy would eliminate the conflict and entrapment, but it would increase traffic delay at this intersection. During off-peak periods it would not have any adverse impact on traffic operations. However, during peak periods, protected only phasing may worsen traffic conditions and also affect signal coordination along Main Street and Weston Street. The proposed phasing pattern is shown in Figure 3-6. Because the safety at this intersection over a three-year period is below average, we recommend that during peak periods a permitted-protected phase plan be restored if traffic delays worsen.

Addressing Access and Safety Problems at Livingstone Lane/Sibley Road Near Route 128

Traffic volumes on Livingstone Lane are not at the level to warrant installation of a traffic signal. Also, this intersection being so close to the Route 20/Route 128 rotary interchange precludes installation of traffic signal. The side road sign (W2-3) and the 30 mph speed limit sign on Weston Street (see Figure 3-7) intended to warn motorists of the presence of an obscured side street and to slow down, do not give drivers enough time, because they are located too close to Livingstone Lane. We recommend the following measures to improve access and safety at this intersection:

- *Install a Left Turn Prohibition Sign (R3-3) at Livingstone Lane and Sibley Road*

  Installation of a left-turn-prohibition sign, "NO LEFT TURN" (R3-1), is recommended on Livingstone Lane and Sibley Road, as shown in Figure 3-7. The left-turn maneuvers from Livingstone Lane and Sibley Road are not safe, considering the heavy traffic on Weston Street and the poor sight distances. At Livingstone Lane, motorists should turn right and go around the rotary interchange to go eastbound on Weston Street. At Sibley Road, traffic can proceed more safely by taking a right turn onto Weston Street, then turning left at the flashing beacon at Stow Street, and then taking Tavern Road back to Weston Street westbound.

  If this recommendation were to prove too restrictive, we would recommend restricting the left-turn prohibition to the peak periods: 7:00-9:00 a.m. and 4:00-6:00 p.m., Monday through Friday.

- *Widen the Approach of Livingstone Lane*

  To make it easier to turn right from Weston Street westbound onto Livingstone Lane, we suggest that the approach of Livingstone Lane be widened by a small amount sufficient to provide adequate room at the approach to accommodate two vehicles, one waiting at Livingstone Lane and the other turning right from Weston Street onto Livingstone Lane. In this way, traffic on Weston Street would not have to slow down to a crawl to make a right turn onto Livingstone Lane when there is a vehicle waiting to exit that approach.

- *Move the Speed Limit Sign and the Obscure Road Sign (in the Direction of Weston Street/ Cedarwood Avenue/Tavern Road Intersection)*

  To give motorists ample time to slow down to make a right turn from Weston Street westbound onto Livingstone Lane, we recommend that the 30 mph speed limit sign and the obscure road sign be moved in the direction of the Weston Street/Cedarwood Avenue/Tavern Road intersection. This strategy would help prevent motorists from accelerating to speeds over 30 mph before beginning to slow down and help prevent rear-end collisions as vehicles slow down to turn onto Livingstone Lane.

FIGURE 3-5

Proposed Improvements to Address the Signal Indication Problem at the Westbound Approach of Weston Street at the Intersection with Cedarwood Avenue/Tavern Road in Waltham

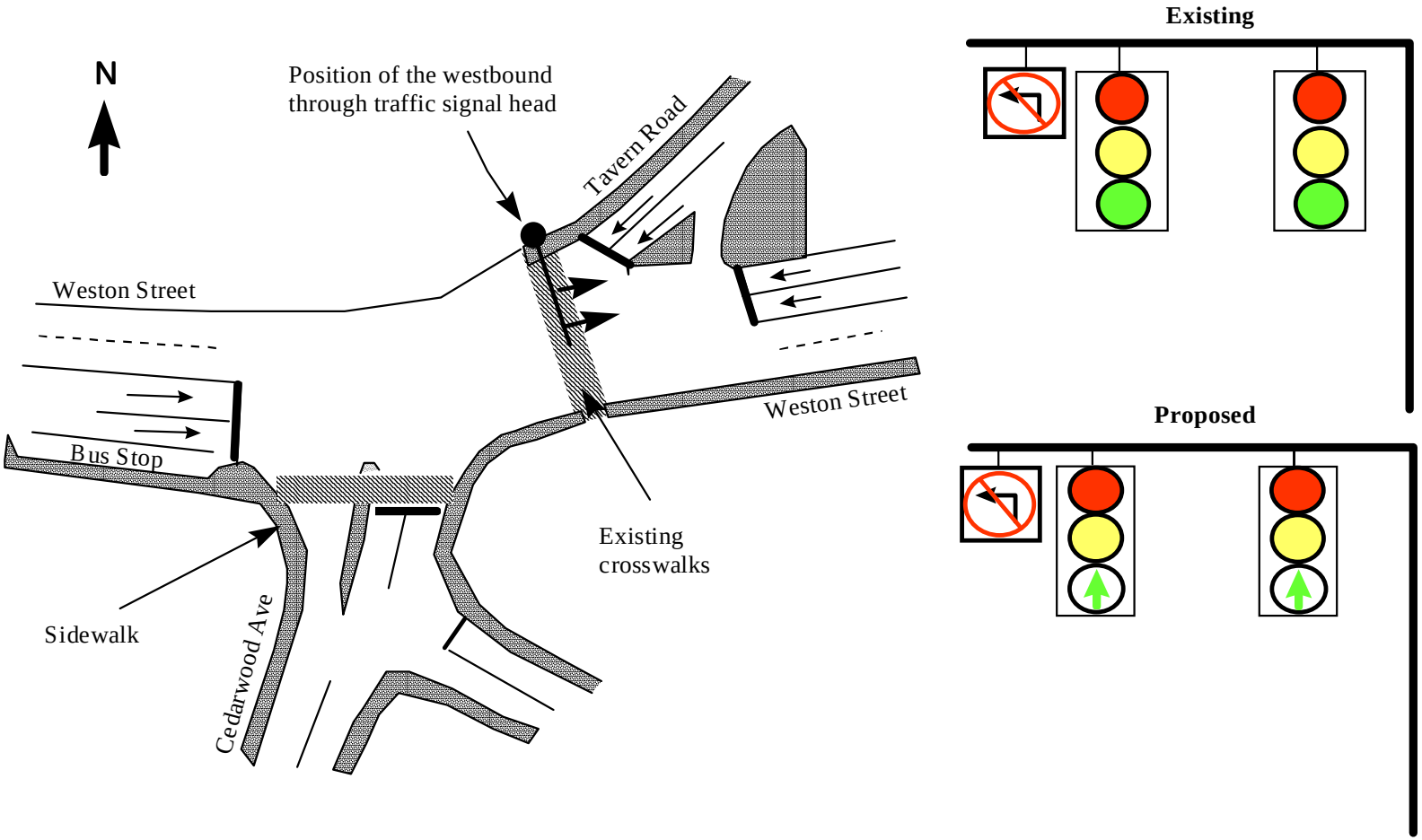


FIGURE 3-6

Proposed Strategy for Improving Safety at Banks Square Intersection in Waltham

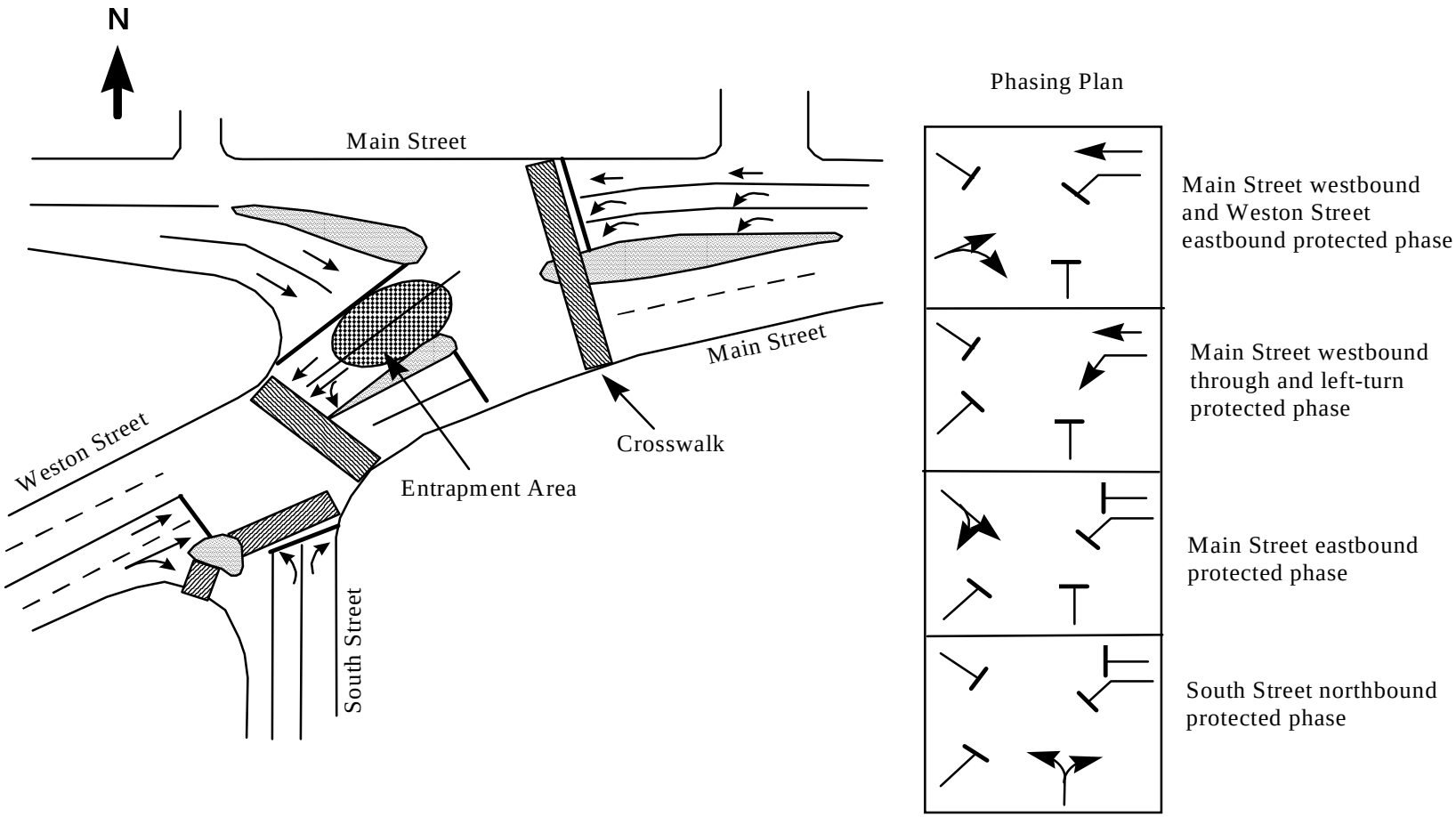
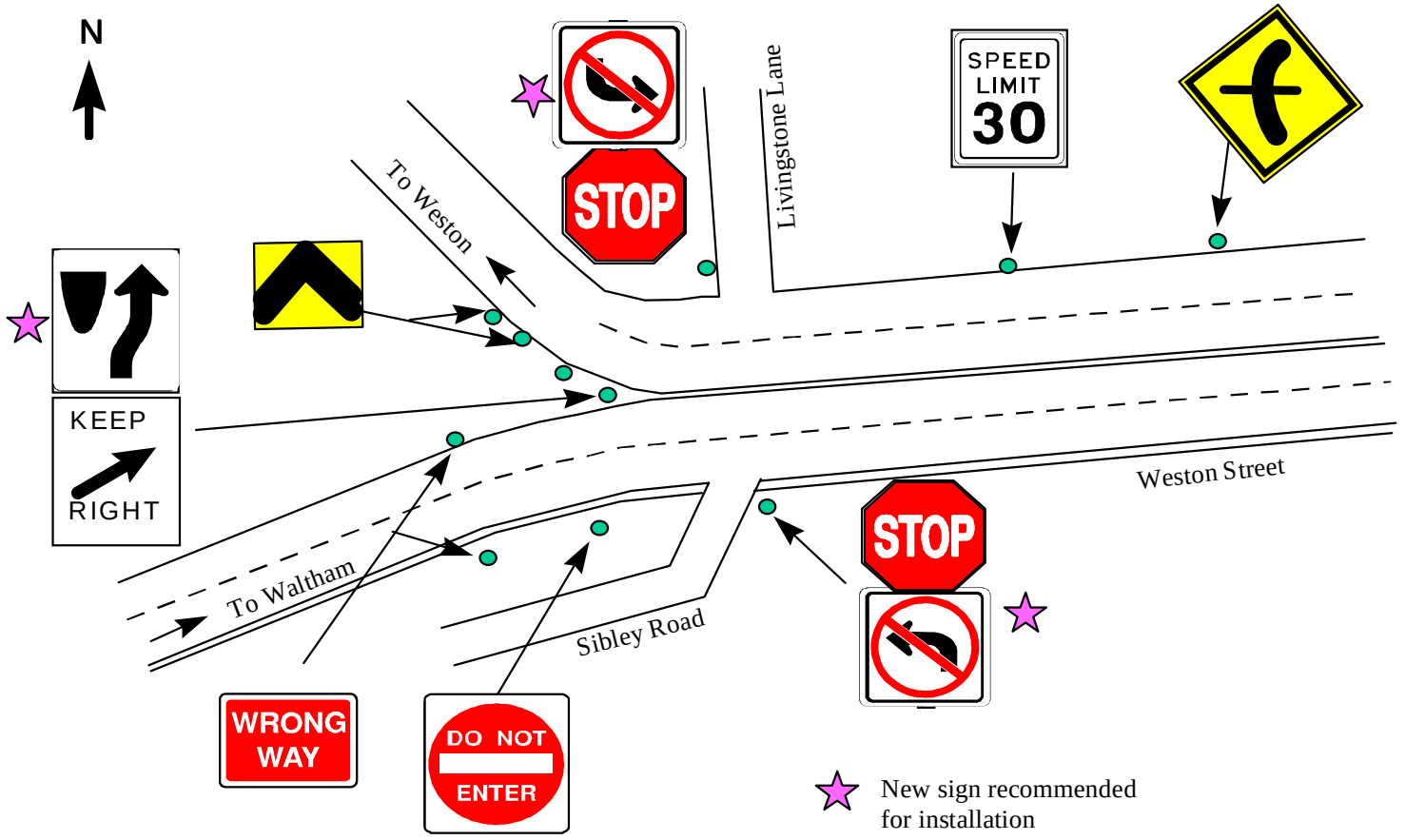


FIGURE 3-7

Signage at Weston Street, Livingstone Lane, Sibley Road, and Route 20/Route 128 Rotary Interchange in Waltham



Addressing Safety Problem at Route 20/Route 128 Rotary Interchange

The traffic and safety problems at this interchange is documented in Chapter 2, section 2.2.6. To improve safety and access from Livingstone Lane, Sibley Road, and the Route 20/Route 128 rotary interchange, we suggest the following improvements:

- *Install a Larger Keep-Right Sign (R4-7*)

  To address the problem of motorists entering the wrong way at the westbound approach on Weston Street at the Route 20/Route 128 rotary interchange, we are proposing that a keep right (R4-7) sign, as shown in Figure 3-7, be installed in addition to the existing "KEEP RIGHT"-with-arrow (R4-7b) sign. The existing "KEEP RIGHT"sign should also be enlarged. Both signs should be mounted on the same post to complement each other and reinforce compliance. They should be mounted at least four feet from the ground level in the median. We believe that this R4-7 sign, which is more symbolic is well-understood by motorists.

- *Reduce Speed Limit at the Route 20/Route 128 Rotary Interchange*

  To improve safety at this location, we recommend that the speed limit on Route 20/Route 128 rotary interchange be reduced from the current 35 mph to 30 mph. In addition, a large yield sign should be installed at the ramp entrance to Route 20. If practical, a combination of a yield sign and a flashing yellow signal light should be used at this location to warn motorists and draw their attention to the need to yield before entry.

3.2 STRATEGIES TO ADDRESS TRANSIT-RELATED PROBLEMS

In 1992 and 1993, the implementation of the Waltham Central Square Urban Systems Project comprehensively addressed public transit problems in the Waltham area, including park-and-ride demand at the Central Square Parking Deck. The two transit problems identified by this study in the Waltham Central Square area are: (1) traffic signal delay facing Route 70 bus service and (2) inadequate parking capacity for commuter rail users.

3.2.1 Reducing Traffic Signal Delay Facing Route 70 Bus Service

Because traffic signal delays impair service quality for the Route 70 buses, specifically schedule adherence and timed transfers, we recommended retiming and coordinating the traffic signals along Route 20 in Waltham and Watertown. The estimated benefits from these measures are shown in Table 3-6 for the Route 70 service. On the average, traffic management improvements could save the bus service 3-4 minutes per trip. Detailed computations of the benefits are included in Appendix E of this report.

TABLE 3-6

Cumulative Bus Passenger Hours of Delay, Route 70 Bus Service

		Eastbound		Westbound	
Condition	**Peak Hour**	**Delay per Trip (minutes)**	**Pax Hours of Delay**	**Delay per Trip (minutes)**	**Pax Hours of Delay**
Existing	AM	9.5	12.0	8.5	8.5
	PM	8.5	8.2	7.6	15.4
With Traffic Improvements	AM	3.8	4.4	3.7	4.4
	PM	3.9	4.2	3.2	6.6

3.2.2 Park-and-Ride at Waltham Central Square Station

About 45-75 parking spaces are needed near the Waltham Central Square station to handle commuter rail passengers who park at the MBTA lot on Moody Street and the Carter Street lot. The City of Waltham will be increasing the parking spaces at the Embassy Lot from 180 to 300 spaces, and this will take care of the problem (see Figure 3-8). The City has introduced a parking sticker program that allows long-term parking at any of the city's all-day-meter (10-12-hour limit) parking lots. A monthly sticker for this program costs $15.00. The program has been successful and is receiving increased patronage each month.

In addition to the City's efforts, we are recommending the following measures to further improve the park-and-ride access to Waltham Station.

1. Improved signing to direct commuters to surrounding alternative parking lots. Signs should be installed along Main Street, Moody Street, and School Street to direct motorists.

2. Advertise and market parking availability in the area of Waltham Station. Small maps or brochures indicating parking locations, availability or usage rate, and fees

should be prepared for distribution at local libraries, city hall, and other public places to inform the public.

3.3 STRATEGIES TO IMPROVE BICYCLE TRANSPORTATION

This study identified several access and safety issues for bicycle transportation in the Route 20 corridor, especially in Waltham and Watertown. These issues include bicycle storage facilities at major transit transfer points and at park-and-ride lots, safety of bicyclists along Route 20, and integration of bike paths and trails in the two communities. We are making the following recommendations to improve access and safety for bicyclists.

3.3.1 Install Bike Storage Facilities

Provision of bicycle storage facilities (e.g., bicycle lockers) is recommended at the MBTA park-and-ride lot at Waltham Station and at the Waltham Central Parking Deck to facilitate biking to access the MBTA bus and commuter rail services.

3.3.2 Increase Signal Clearance Time

Increasing the clearance time (yellow plus all-red time) from 4 seconds to 7 seconds along Main Street at its intersections with Barbara/Gore streets and Warren Street is recommended. This would allow bicycles to clear the intersections. Extension of the clearance time will not have any adverse impact on traffic delay at those intersections.

3.3.3 Install Bike Signs

Provision of bike signs is recommended along Route 20 to inform motorists of bike traffic and to share the road with them. This would improve the safety of bicyclists.

3.3.4 Integration of Bicycle Transportation

It is recommended that the feasibility of providing a continuous bike lane between Waltham and Watertown to link with the Charles River bicycle path be examined. Such integration would provide bicycle transportation access to the public transit systems in the two communities, as shown in Figure 3-9.

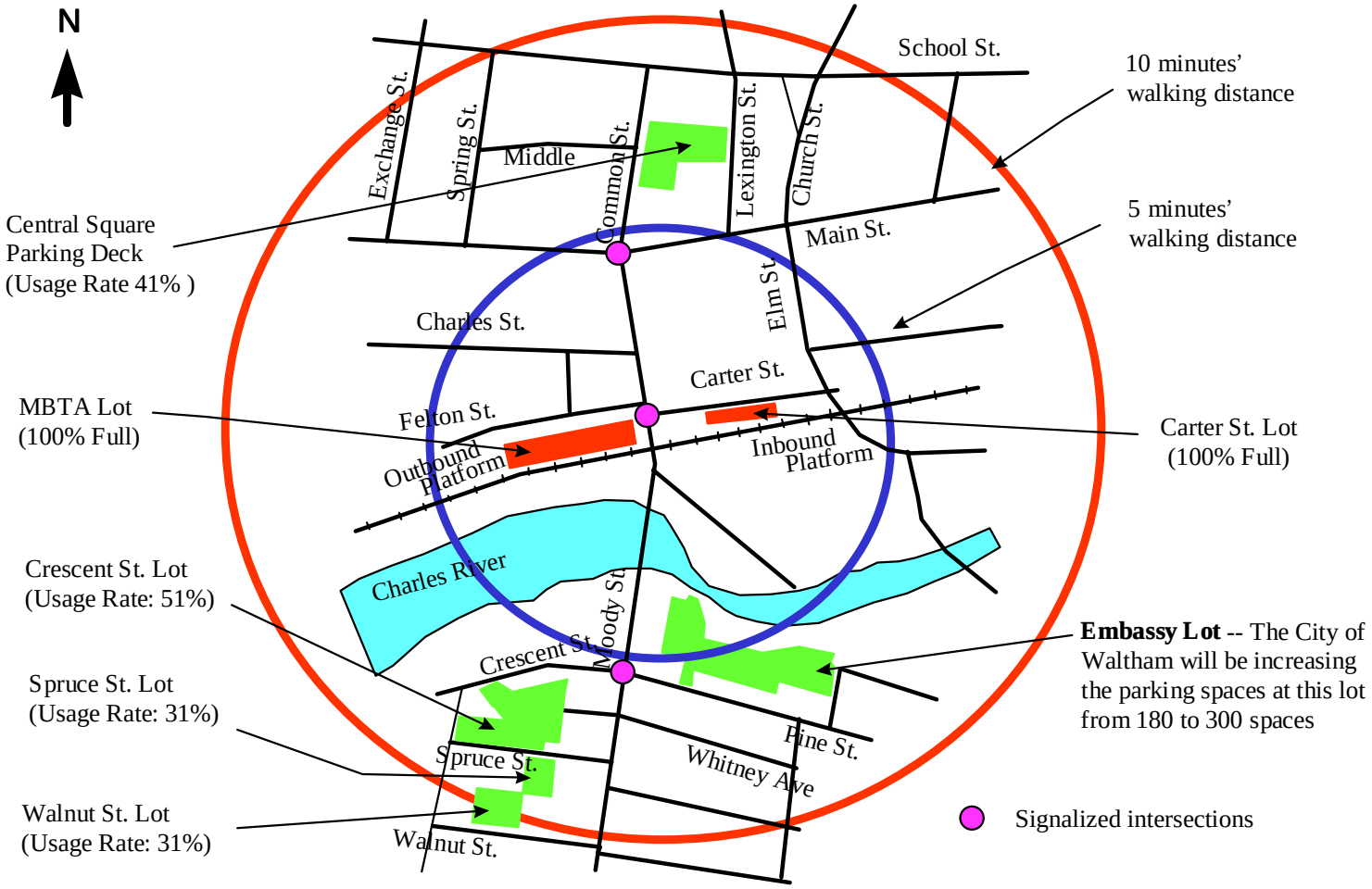
Candidate streets in Waltham for this proposal include River Street, Grove Street, and Pleasant Street. The detailed evaluation should include space for reasonable bike accommodation, smooth paved surfaces for the bicycle lane, desirable sight distances measured from the bicycle lane, consistent treatment (signing and safety measures), and connection to a

bikeway system. Design standards must comply with American Association of State Highway and Transportation Officials (AASHTO) and MUTCD guidelines.

The MassHighway benchmark for reasonable bike accommodation[7] is to provide a continuous paved usable shoulder adjacent to the outside travel lane in each direction of the roadway where bicycles are legally permitted. The desirable width of the outside travel lane plus the paved usable shoulder (curb lane) is at least 5.0 meters (plus 0.5-meter "guardrail" offset). When this width cannot be reasonably accommodated, the minimum width of the outside travel lane plus the paved usable shoulder is 4.5 meters (plus 0.5-meter offset). For roadways with low volumes of less than 2,000 average annual daily traffic (AADT), the minimum roadway widths as defined in Chapter 8 of the Highway Design Manual may be used to conform with bicycle accommodation.

[7] *MassHighway Engineering Directive* E-97-004, dated 7/1/97, "In Response to MGL Ch 87Acts of 1996 - Bicycle and Pedestrian Accommodation."

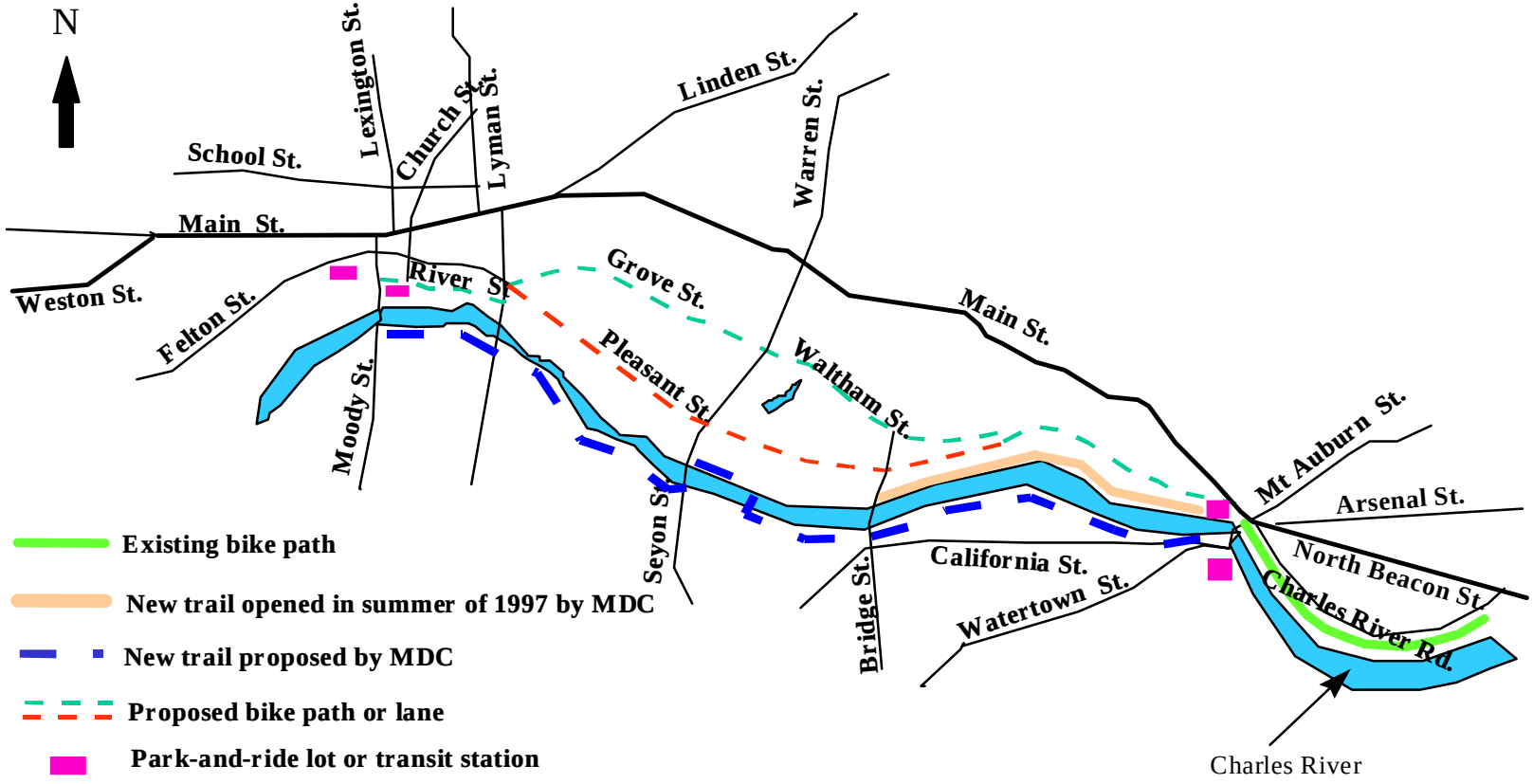
FIGURE 3-8
Parking Access and Availability at Central Square in Waltham



These lots are owned, maintained, and operated by the City of Waltham

FIGURE 3-9

Candidate Streets for Bike Lane Integration Waltham and Watertown



4. PROPOSED STRATEGIES TO ADDRESS PROBLEMS IDENTIFIED IN WATERTOWN

In Chapter 2, we described the transportation problems identified in the Route 20 corridor for all three communities (Waltham, Watertown, and Boston). This chapter, describes our recommended strategies for addressing the problems identified in Watertown. Like previous chapters, this chapter is organized by mode of transportation: highway, transit, and non-motorized means such as bicycling and walking.

4.1 STRATEGIES TO ADDRESS ARTERIAL AND INTERSECTION-RELATED PROBLEMS

As documented in Chapter 2, three signalized intersections in Watertown along Route 20 (Main Street) have significant traffic delays and need improvements to facilitate traffic flow. We are proposing several improvements that can be implemented within the existing right-of-way to improve traffic operations and safety. These improvements include signal retiming, upgrading of the existing signal equipment (signal controller), and adding left-turn storage bays. The intersections involved are (see Figure 4-1):

1. Watertown Square - Main Street at Mt. Auburn Street/Galen Street/Arsenal Street/Charles River Road. Proposed improvements for this intersection are described in detail in section 4.1.1.

2. Main Street at Waverly Avenue and Myrtle Street. Proposed improvements at this intersection can be found in section 4.1.2.

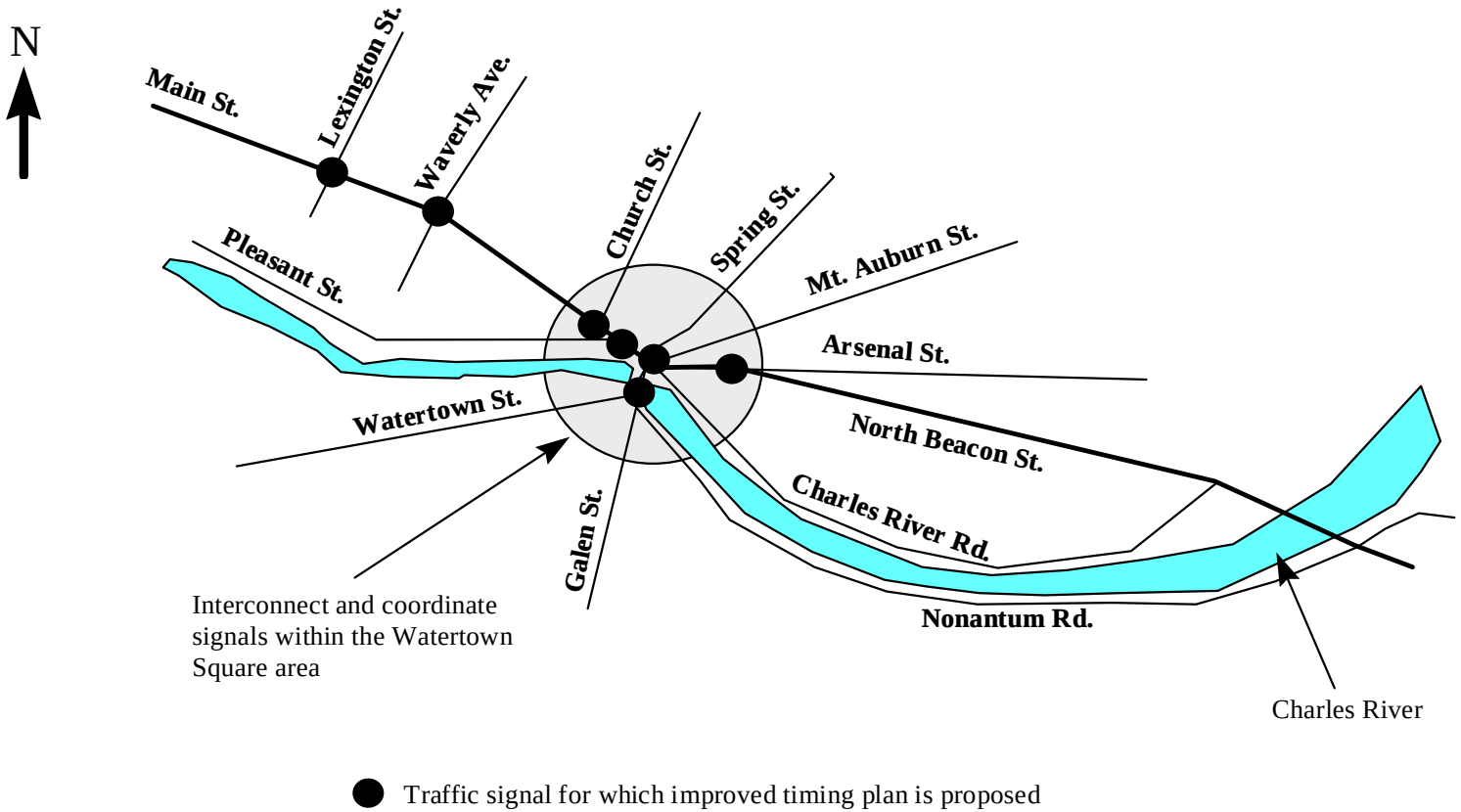
3. Main Street at Lexington Street. Improvements proposed for this intersection are described in section 4.1.3.

4.1.1 Addressing Traffic Delays at Watertown Square

This intersection is controlled by the Town of Watertown. Its traffic signals are interconnected and coordinated with the surrounding traffic signals at the intersections of Main Street with Church Street, and Pleasant Street. During the peak periods, it experiences significant traffic delays and long queues of traffic backing up into the adjacent traffic signals. This significantly affects bus transit serving the Watertown and Waltham areas. All approaches to the Watertown Square intersection are operating at an unacceptable level of service (LOS F), and traffic operations at this intersection adversely affect the surrounding intersections.

FIGURE 4-1

Traffic Signals in Watertown Proposed for Retiming



Traffic queues spill over from this intersection to the Arsenal Street, Church Street, and Watertown Street intersections, causing gridlock in this vicinity. Our analysis indicates average queue lengths of 18 vehicles per lane at the approaches of Galen Street, Main Street, and Arsenal Street during the peak periods. We are proposing retiming this traffic signal, interconnecting and coordinating it with the surrounding traffic signals, and upgrading the existing signal controller, as described below.

- *Retime Watertown Square Traffic Signal*

  Under this plan, only signalization improvements are proposed; the present intersection geometry and lane assignments are not altered. The levels of service estimated to result from retiming at each of the five approaches are as shown in Table 4-1 and Figure 4-2. All the approaches would operate at LOS E or better. Detailed intersection capacity analysis for this intersection is included in Appendix D of this report.

- *Interconnection and Coordination of Signals*

  Because the Watertown Square intersection is operating at capacity (volume to capacity [v/c] ratio of 1.02), improvements in signal timing plans alone cannot reduce traffic delay to acceptable levels. Space limitations preclude any geometric improvements such as adding more lanes. For maximum benefits, it is recommended that the Watertown Square signal be interconnected with other traffic signals in the vicinity.

  By interconnecting and coordinating this signal with the surrounding ones, a closed-loop system can be provided whereby all traffic signals can be operated as a group from a single computer to improve the overall traffic operations in the area. This is necessary because the surrounding signals are located so close to the Watertown Square signal. A closed-loop system would greatly enhance traffic flow by making it easier for updating timing information to controllers to allow coordination. Furthermore, a closed-loop system would offer the capability of transferring priority from one street to another and providing traffic preemption to clear traffic queues before they spill over to adjacent traffic signals.

  Implementing a closed-loop system will require updating the existing controllers, communication equipment and links for monitoring detectors and transmitting data, installing a central office computer to store timing information, and using traffic management software programs to analyze detector data to ensure that the correct pattern for current conditions is implemented.

The following are candidate traffic signals for interconnection with the Watertown Square traffic signal:

1. Watertown Street, Nonantum Road, and Galen Street signal.

2. North Beacon Street and Arsenal Street signal

4.1.2 Main Street and Waverly Avenue/Myrtle Street in Watertown

The Main Street and Waverly Avenue/Myrtle Street traffic signal is a pretimed three-phase plan; the pedestrian phase is pedestrian-actuated. The Town of Watertown has jurisdiction over this intersection. Presently, it is not operating efficiently because the Main Street eastbound left turns sometimes block the straight-through traffic during the peak periods. Because the Main Street eastbound approach is wide enough to accommodate two traffic lanes, drivers sometimes form a de facto left-turn lane from Main Street onto Waverly Avenue. To improve traffic operations at this intersection we recommend the following measures:

TABLE 4-1

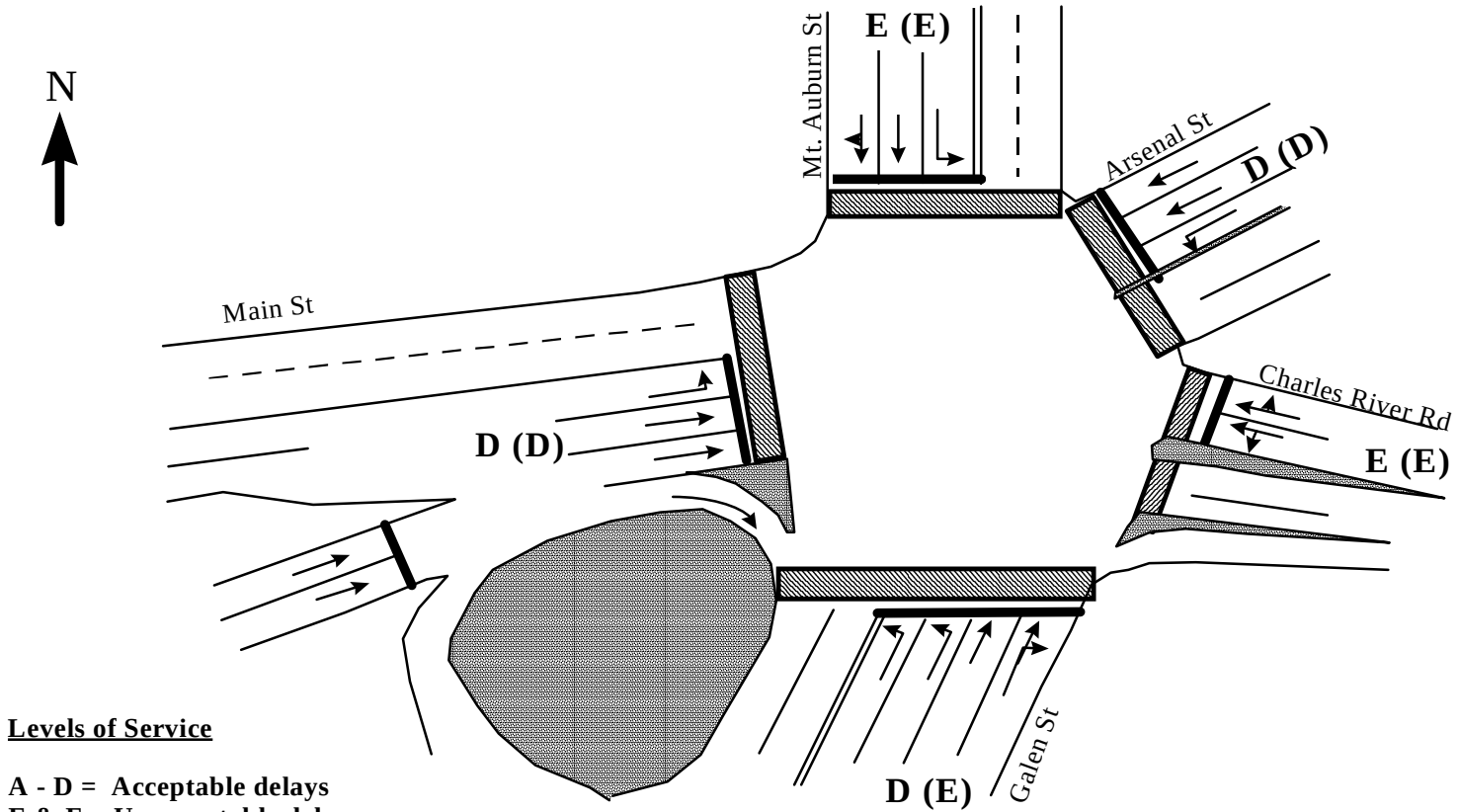
Approach Delays and Levels of Service Estimated to Result from Retiming Traffic Signals Along Route 20 (Main Street) in Watertown

		Approach Delay and Level of Service (seconds per vehicle)			
Intersection	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
Main Street @ Galen Street,Mt. Auburn Street, Arsenal Street, and North Beacon Street	AM	34 (D)	35 (D)	30 (D)	46 (E)
	PM	38 (D)	37 (D)	53 (E)	50 (E)
Main Street @ Waverly Avenue/Myrtle Street	AM	10 (B)	30 (D)	24 (C)	38 (D)
	PM	13 (B)	34 (D)	31 (D)	35 (D)
Main Street @ Lexington Street	AM	19 (C)	42 (E)	9 (B)	43 (E)
	PM	11 (B)	10 (B)	14 (B)	34 (D)

Charles River Road operates at LOS E during peak hours.

FIGURE 4-2

Levels of Service Projected to Result from Signal Retiming at Watertown Square Intersection



- *Provide a Left-Turn Bay at the Eastbound Approach*

  Restriping the Main Street eastbound approach to provide an exclusive left-turn bay is recommended, to prevent left-turners from blocking the through traffic (see Figure 4-3). The existing roadway width at this intersection is sufficient to accommodate this improvement, and no land-taking or encroachment is required.

- *Retime Signal and Provide a Protected-Permitted Phase for the Eastbound Approach*

  Retiming this signal to provide a protected-permitted phasing plan for the Main Street eastbound traffic is recommended to reduce traffic delays. This strategy would yield acceptable levels of service (LOS D or better) at all the approaches and provide safer and more efficient traffic operations (see Table 4-1 and Figure 4-3). Semi-actuated signal controls with loop detectors at the intersection to sense traffic is recommended to allow the main-street phases to have maximum recall and show maximum green times while the side-street phases may be actuated, gap-out early, or be skipped entirely. Interconnecting this signal with the one at Lexington Street would also allow coordination of the two traffic signals to improve traffic flow through this pair of signals.

4.1.3 Main Street and Lexington Street

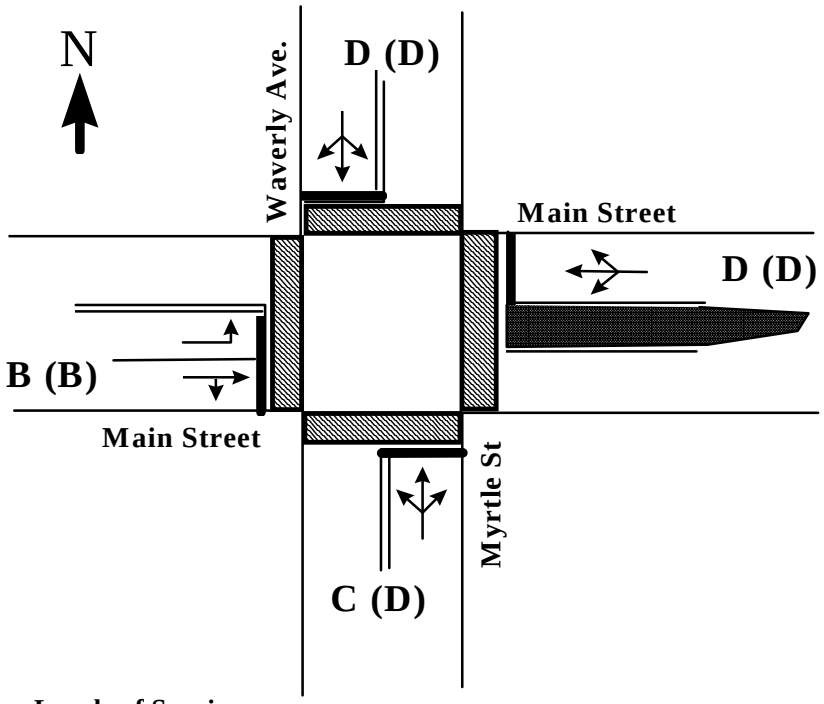
This signalized intersection is controlled by MassHighway. Presently, it has a three-phase plan, including a pedestrian-actuated phase. Because it is striped as one lane at all approaches, Main Street eastbound left turns interrupt traffic flow, especially during the peak periods, as they turn permissively. Currently, both approaches on Main Street and Lexington Street southbound approaches operate at LOS F and LOS E, respectively. The Main Street westbound approach also experiences significant delay whenever the pedestrian phase is called during the peak periods. To improve traffic flow at this intersection, we are proposing the following intersection improvements:

- *Restripe Both Approaches on Main Street to Accommodate Turn Bays*

  To facilitate traffic flow at this intersection we are proposing that both approaches on Main Street be restriped to accommodate a left-turn bay, as shown in Figure 4-4. A three-phase signal plan as shown in Figure 4-4 is also proposed, along with a semi-actuated signal operation. With these improvements, all approaches would have LOS E or better. Because the distance between the intersections of Main Street with Waverly Avenue/Myrtle Street and Lexington Street is less than one-half mile, interconnecting them to provide coordination is also recommended.

FIGURE 4-3

Proposed Improvements at the Intersection of Main Street and Waverly Avenue/Myrtle Street in Watertown with Estimated Levels of Service

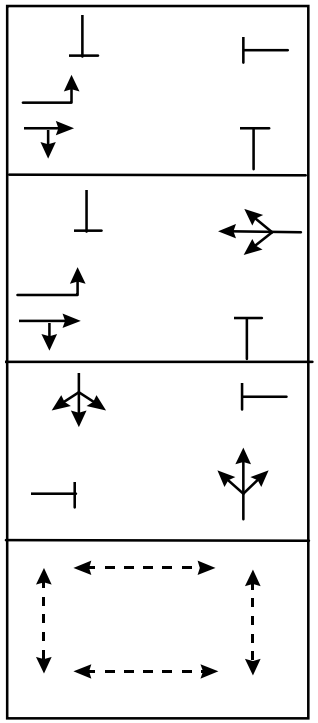


Levels of Service

A - D = Acceptable delays
E & F = Unacceptable delays

AM (PM)

Phase Plan for AM and PM Peak Periods



Eastbound protected phase

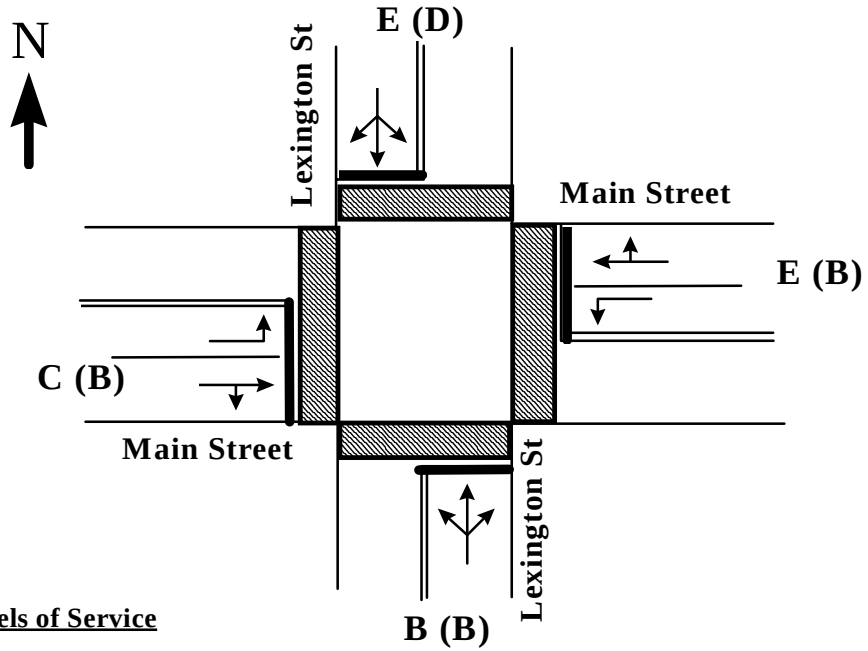
Eastbound and westbound permitted phase

Northbound and southbound permitted phase

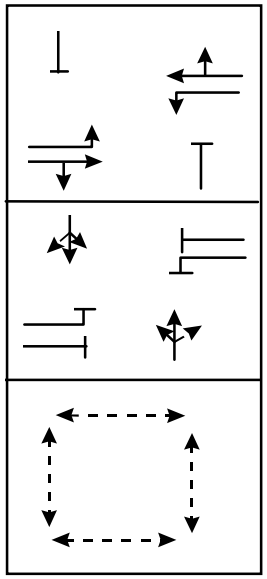
Pedestrian actuated phase

FIGURE 4-4

Proposed Improvements at the Intersection of Main Street and Lexington Street in Watertown with Estimated Levels of Service



Phase Plan



Eastbound and westbound permitted phase

Northbound and southbound permitted phase

Pedestrian actuated phase

Levels of Service

A - D = Acceptable delays
E & F = Unacceptable delays

AM (PM)

4.1.4 Strategies to Improve Traffic Flow on North Beacon Street at the Town Line of Watertown and Boston (Brighton)

The Metropolitan District Commission (MDC) has jurisdiction over three signalized intersections located on North Beacon Street in Brighton near the town line with Watertown. We included this segment of Route 20 in this chapter because these intersections affect recreational activities and traffic operations in Watertown more than in Brighton (also, the City of Boston does not have jurisdiction over these intersections). These three intersections are shown in Figure 4-5.

Presently all three intersections are failing during the peak periods. There are long queues of traffic at the North Beacon Street eastbound approach and at the Parsons Street northbound approach during peak periods. The present 150-second cycle length for the westside intersection results in high delays for Parsons Street and Birmingham Parkway. Because the traffic signals are not synchronized, eastbound vehicles from North Beacon Street and Nonantum Road are sometimes released at the same time. When this happens, the two traffic streams have to weave and merge with each other to continue either on North Beacon Street or on Soldiers Field Road, which causes safety problems. We have conducted detailed assessments of these intersections and are making the following recommendations:

- *Retime Traffic Signals and Widen Parsons Street Approach to Accommodate Two Lanes*

  Because longer cycle lengths typically lead to longer delays, a shorter cycle length of 120 seconds is proposed. The advantage of a shorter cycle length is that the approaches are serviced more frequently, resulting in shorter delays when demand is below capacity. The phase time for all movements should be reduced proportionally to achieve this cycle length. In addition to these signal retiming improvements, we recommend that the Parsons Street approach be widened to accommodate two traffic lanes. Site inspection indicated that enough space is available to accommodate an additional lane for storing up to four or five vehicles at this approach. The existing intersection geometric layout and lane configurations are maintained at the other approaches (see Figure 4-5).

  At the remaining two intersections (Nonantum Road at Brooks Street and North Beacon Street at Soldiers Field Road/Nonantum Road), a cycle time of 120 seconds is proposed. We recommend that both signals be retimed using the proposed cycle length. With these improvements, the levels of service at all three intersections would be acceptable (LOS D or better), as shown in Table 4-2.

- *Synchronized Traffic Signals*

  In addition to the signal retiming, we are proposing that the three traffic signals in this vicinity be interconnected and synchronized. Synchronizing the traffic signals is necessary to minimize weaving and merging of the eastbound traffic from Nonantum Road and North Beacon Street. If the traffic signals are synchronized, vehicles will flow

FIGURE 4-5

Proposed Improvements at the MDC Traffic Signals at the Town Line of Watertown and Boston (Brighton) with Estimated Levels of Service

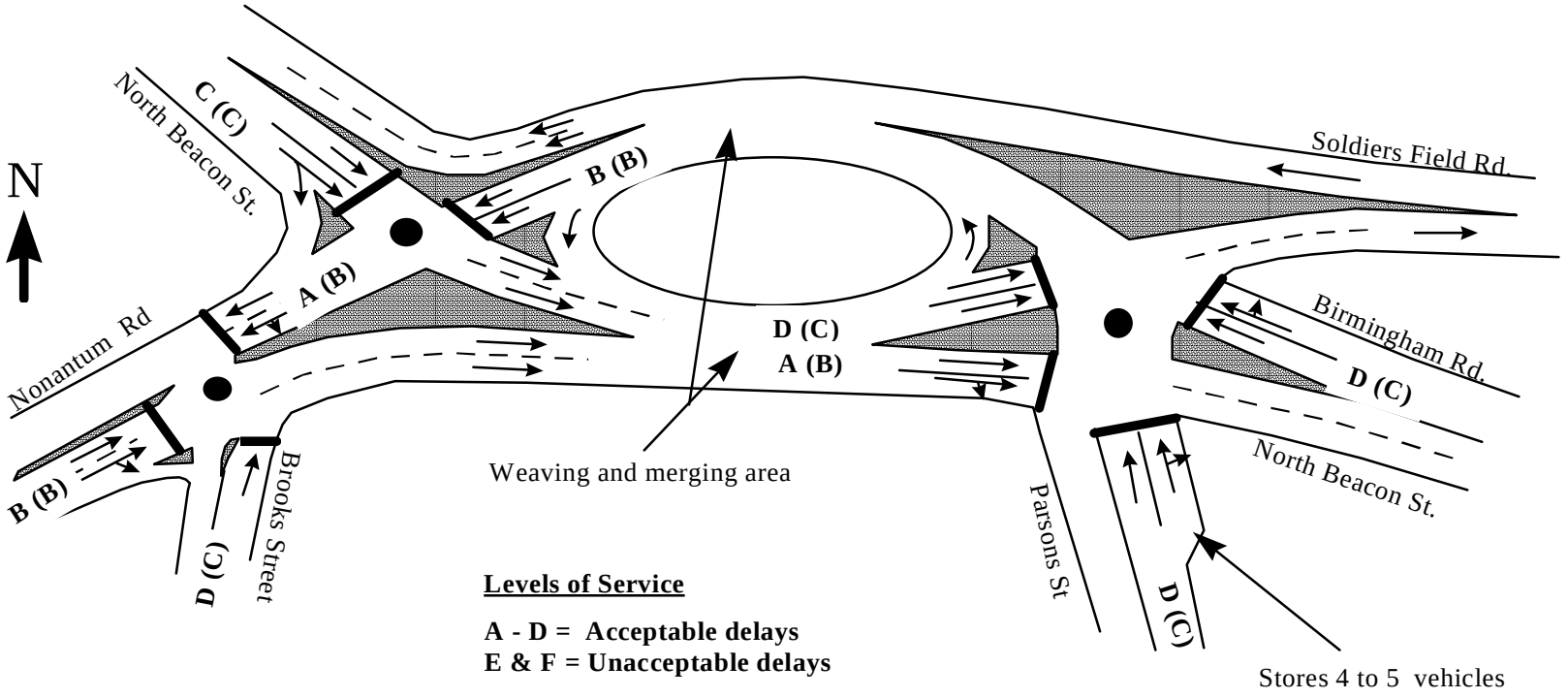


TABLE 4-2

Estimated Approach Delays and Levels of Service for MDC Intersections with Proposed Improvements

		Approach Delay and Level of Service (seconds per vehicle)			
Intersection	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
North Beacon Street @ Birmingham Parkway/Parsons Street	AM	17 (C)	31 (D)	29 (D)	_
	PM	13 (B)	23 (C)	25 (C)	_
North Beacon Street @ Nonantum Road/Soldiers Field Extension Road	AM	_	7 (B)	_	22 (C)
	PM	_	11 (B)	_	24 (C)
Nonantum Road @ Brooks Street	AM	11 (B)	10 (B)	36 (D)	_
	PM	8 (B)	18 (C)	20 (D)	_

efficiently through the intersections and the chances of traffic queues blocking the intersections will be reduced significantly. A traffic synchronization plan for the three intersections is shown in Figures 4-6 and 4-7 for both peak periods. The arrows represent the movements permitted during each signal phase along with their duration in seconds. Field operations will require fine-tuning to determine the appropriate offsets.

It should be pointed out that the weaving and merging traffic in this vicinity can reduce the estimated levels of service at these intersections. This study did not consider the impact of future traffic growth and the problem of who has priority at the weaving and merging sections. Hence, the proposed strategies are short term solutions to traffic problems at these intersections. A detailed study is proposed to find long term solutions to traffic problems in this vicinity.

FIGURE 4-6

AM Peak Phasing Patterns and Sequences for Signal Synchronization at the MDC Traffic Signals (Watertown/Boston)

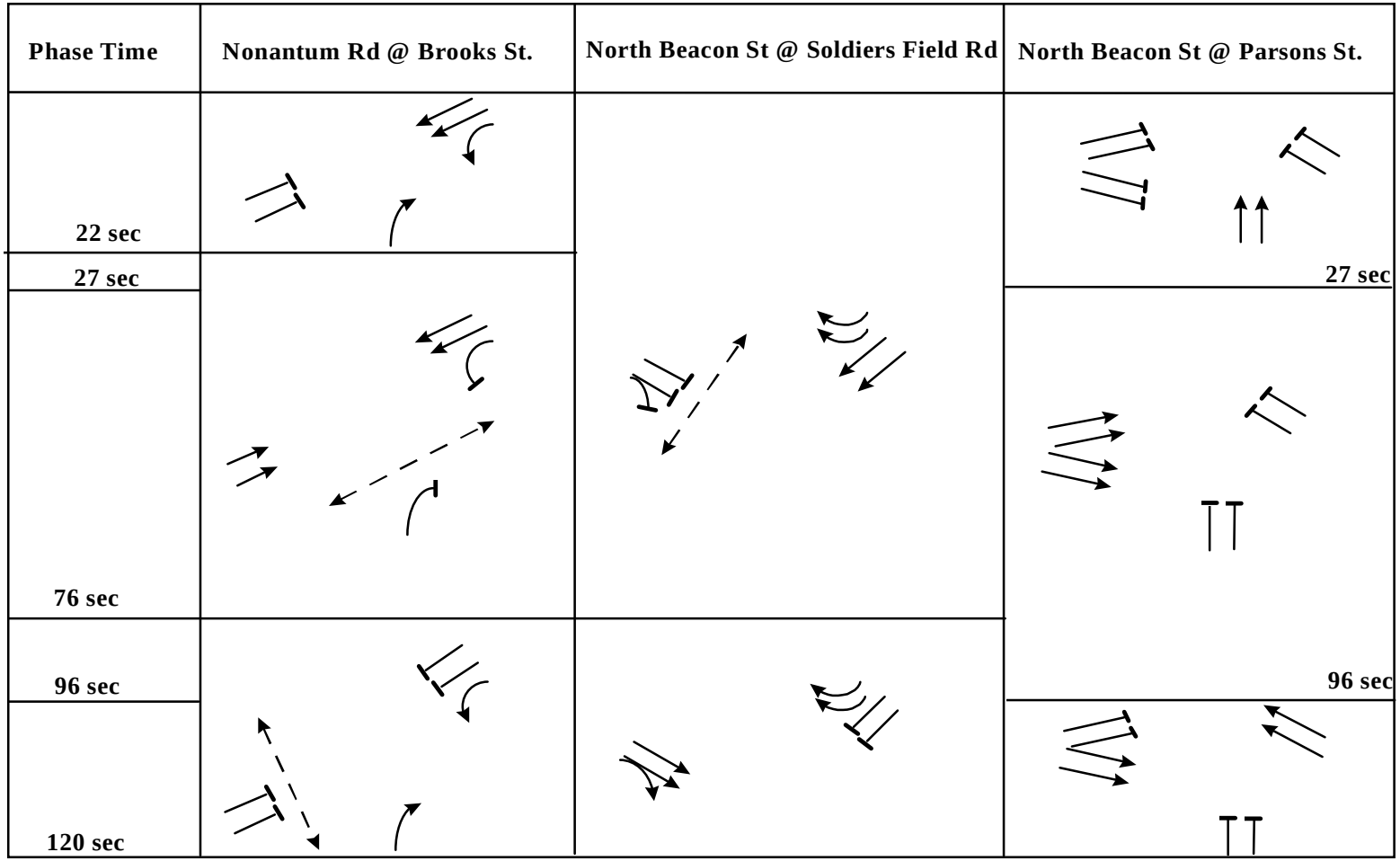
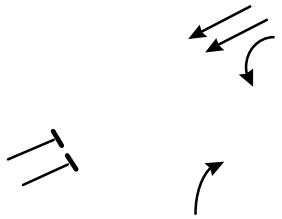
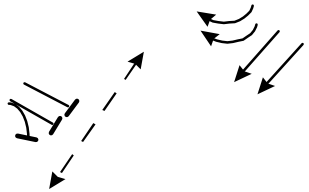
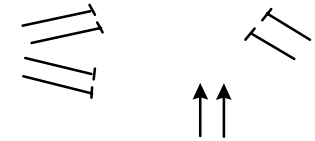
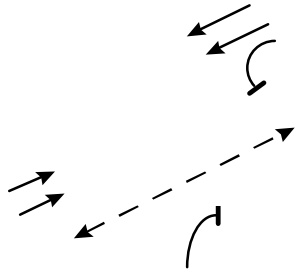
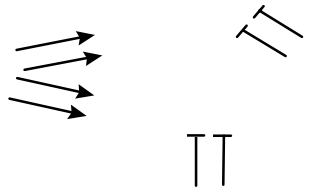
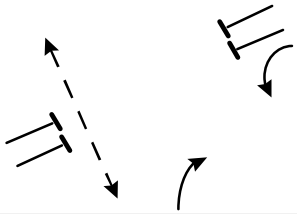
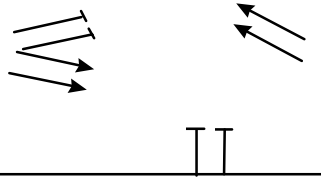


FIGURE 4-7

PM Peak Phasing Patterns and Sequences for Signal Synchronization at the MDC Traffic Signals (Watertown/Boston)

Phase Time	Nonantum Rd @ Brooks St.	North Beacon St @ Soldiers Field Rd	North Beacon St @ Parsons St.
25 sec			
40 sec			25 sec
86sec			
120 sec			

4.2 STRATEGIES TO ADDRESS TRANSIT-RELATED PROBLEMS

Two transit-related problems were identified in the study area in Watertown: (1) difficult passenger transfers between the Watertown Square and Watertown Yard terminals and (2) low schedule adherence for bus routes 57 and 70. Both problems are documented in Chapter 2 in the section on transit-related problems.

4.2.1 Passenger Transfers Between the Watertown Square and Watertown Yard Terminals

Passenger transfers between the Watertown Square and Watertown Yard terminals are not easy: passengers have to cross the bridge over the Charles River and two busy intersections. Under normal circumstances this can take about five minutes. Over 500 passenger transfers take place between the two terminals each day.

To address the transfer problem, we examined several alternatives, including extending some routes from Watertown Yard terminal to the Watertown Square terminal. However, for all the alternatives examined, the safety and operations costs involved far outweigh the benefits. There is not sufficient space at the Watertown Square terminal to accommodate additional buses. In addition, the platforms at the Watertown Square terminal are not large enough to handle high-capacity routes such as Routes 52 and 57; potential safety problems would be one concern.

Another concern is the traffic congestion at Watertown Square. If any route were extended to the Watertown Square terminal it would experience significant traffic delays that would have an adverse impact on schedule adherence. The recently opened MBTA park-and-ride lot at the Watertown Yard terminal has provided enough parking spaces for park-and-ride users of the "T" buses. This eliminated the need for parking elsewhere at the Watertown Square and Watertown Yard terminals.

Considering all factors, we are recommending that the existing route layout and transfers at Watertown be retained.

4.2.2 Improving Schedule Adherence for Bus Routes 57 and 70

Routes 57 and 70 are high-capacity routes serving the Route 20 corridor in the Watertown and Waltham area. Both routes can benefit from the proposed traffic signal retiming and coordination: reduced delays will improve schedule adherence and timed transfers.

The two locations where reductions in intersection delay will benefit buses along Route 20 are: (1) Main Street from Waltham to Watertown for the Route 70 service and (2) Commonwealth Avenue and Brighton Avenue in Boston for the Route 57 service. We are proposing that all critical traffic signals within these two segments of Route 20 be retimed and

coordinated, where appropriate, to reduce traffic signal delays (see sections 3.1.1 in Chapter 3 and 4.1.1-4.1.3 in this chapter). It is expected that bus service along Route 20 will benefit from these improvements, as shown in Table 4-3 (about 3-5 minutes' reduction in intersection delay per trip).

4.2.3 Passenger Crowding on Bus Routes 57 and 70

The MBTA through its Annual Service Plan[8] has proposed several measures to increase ridership, improve efficiency, and meet the Authority's established service standards. The final plan approved in March 1998, includes proposals to address crowding and improve efficiency on bus routes 57 and 70.

- *Route 57, Watertown - Kenmore Square*

  As a result of the observed ridership levels, the final plan recommends increasing frequencies on Sundays from 30 minutes to 20 minutes during the early AM period (start of service-6:59 a.m.) and from 30 minutes to15 minutes during the midday period. It also recommends improving Sunday frequencies between 9:45 a.m. and 12:45 p.m. On Saturdays, the plan recommends that the frequency of service for Route 57 be reduced from 7.5 minutes to 8.5 minutes between 3:25 p.m. and 5:40 p.m. due to excess capacity during this time period. The proposed improvements would be implemented in the summer of 1998.

  Because bunching of vehicles occurs on this route, a traffic management study of the entire route is recommended to find those locations and intersections where the buses face significant traffic delays and to examine strategies which will help achieve schedule adherence. This study examined only bus paths that lie along Route 20. Reducing bunching of vehicles and maintaining schedule adherence can reduce crowding on the Route 57 service. In the short term, reducing the headways of trips scheduled during the morning and evening peak periods to headways that add one or two more buses will reduce crowding.

- *Route 70/70A, Waltham, Watertown - Central Square, Cambridge*

  To meet frequency standards, the MBTA Annual Service Plan has recommended to improve frequency for Route 70/70A during AM peak period (7:00-8:59 a.m.) from every 45 minutes to every 35 minutes on weekdays. The final plan also improves frequency during midday period from every 90 minutes to every 60 minutes on weekdays.
  Due to crowded conditions, the frequency for Route 70 on Sundays is improved from every 18 minutes to every 15 minutes during the late afternoon period. The proposal extended Route 70 service to University Park in Cambridge on weekdays (except evenings), Saturdays, and Sundays.

[8] Fiscal year 1998 (FY98) Annual Service Plan, Massachusetts Bay Transit Authority, March 1998.

As with the Route 57 service, the crowding problem on the Route 70 service is partly attributed to bunching of vehicles. We recommend that a traffic management study be conducted for the remaining portion of the Route 70 path outside the study area to help achieve schedule adherence.

TABLE 4-3

Cumulative Bus Passenger Hours of Delay for Route 57 and 70 Bus Services

			Eastbound		Westbound	
Condition	**Bus Route**	**Peak Hour**	**Delay per Trip (minutes)**	**Pax Hours of Delay**	**Delay per Trip (minutes)**	**Pax Hours of Delay**
Existing	57	AM	5.5	40.3	2.1	5.3
		PM	7.6	17.0	3.5	18.1
With Traffic Improvements	57	AM	3.4	25.2	2.4	6.4
		PM	4.7	12.5	3.9	19.4
Existing	70	AM	9.5	12.0	8.5	8.5
		PM	8.5	8.2	7.6	15.4
With Traffic Improvements	70	AM	3.8	4.4	3.7	4.4
		PM	3.9	4.2	3.2	6.6

Note: These numbers include only the bus paths that lie along the Route 20 arterial.

4.3 PEDESTRIAN CROSSING ISSUES

The major pedestrian issue in Watertown is crossing at the intersection of North Beacon Street and Greenough Boulevard. The problem is documented in Chapter 2 in the section on pedestrian crossing and access issues.

4.3.1 Strategies to Improve Pedestrian Crossing at North Beacon Street and Greenough Boulevard

Crossing North Beacon Street at this location is difficult and dangerous because of the wide roadway; pedestrians have to cross all four traffic lanes at once as there is no median in the roadway. The present crosswalks at this intersection are not functioning well, as they are hardly visible and drivers do not yield to pedestrians. To facilitate crossing at this location, we are proposing the following improvements:

- *Construct a Narrow Median*

  Constructing a narrow median is recommended along North Beacon Street from the intersection of Nonantum Road and Soldiers Field Extension across the Charles River bridge to the Greenough Boulevard intersection. This narrow median, preferably a raised median, as shown in Figure 4-8, would facilitate crossing by allowing pedestrians to cross North Beacon Street in stages instead of crossing all four lanes at once. Also, pedestrians and bicyclists would not have to look for an adequate gap in both directions before they cross. Installation of the median would require reducing the existing lane widths from 12 to 11 feet. The proposed improvement is in line with the recommendations from the Watertown Arsenal Reuse Master Plan[9].

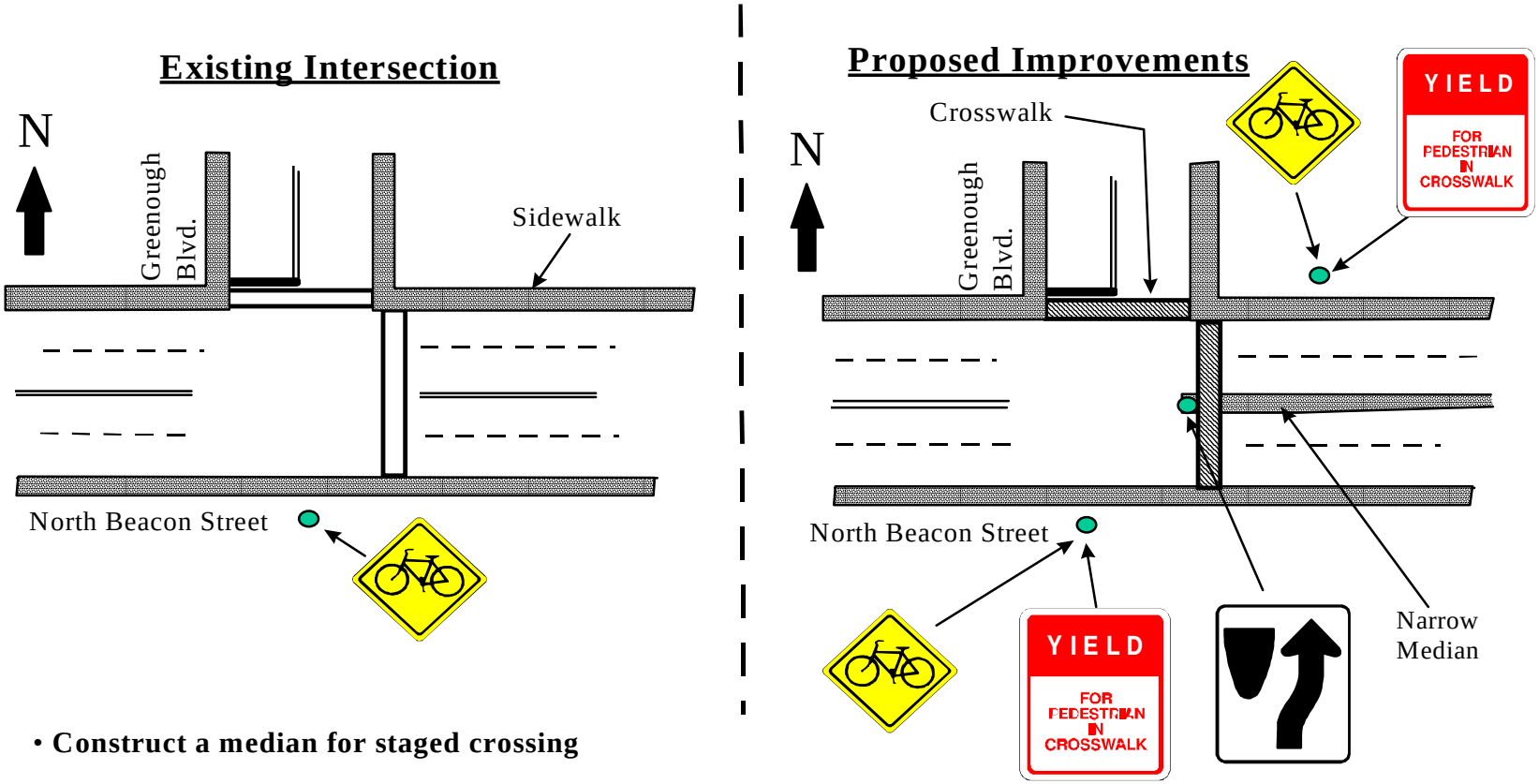
- *Provide Longitudinal Lines Within the Crosswalks and Install Pedestrian Crossing Signs*

  Provision of longitudinal lines in the crosswalks is recommended for added visibility to both motorists and pedestrians. The longitudinal lines should conform with MUTCD standards. A pedestrian crossing sign, "CROSS ONLY AT CROSSWALKS" (R9-2), should be installed to aid in limiting pedestrian crossing to safe places. This should be installed facing traffic in both directions on North Beacon Street. Because this intersection is not signalized, an additional sign, "STATE LAW YIELD TO PEDESTRIANS IN CROSSWALKS," should also be installed at this intersection and a second one placed at an adequate distance in advance of the intersection to warn motorists to stop and allow pedestrians to cross the street.

[9] *Watertown Arsenal Reuse Plan Update, Technical Addenda, Part B, Traffic Impact Analysis,* August 22, 1996.

FIGURE 4-8

Proposed Improvements for Pedestrian Crossing at the Intersection of North Beacon Street and Greenough Boulevard in Watertown



- **Construct a median for staged crossing**
- **Provide longitudinal lines in crosswalk for added visibility**
- **Install pedestrian crossing signs**

4.4 STRATEGIES TO IMPROVE BICYCLE TRANSPORTATION

Bicycle-transportation-related issues identified in Watertown were similar to those in Waltham: a need for bicycle storage facilities, safety of bicyclists along Route 20, and integrating bike routes and trails. These issues have been described in detail in Chapter 2 of this report. The following sections describe our proposals for improving bicycle transportation in the Route 20 corridor in Watertown.

4.4.1 Bicycle Storage Facilities

Provision of bicycle storage facilities (e.g., bicycle lockers) at the MBTA park-and-ride lot is recommended at the Watertown Yard and also at the Watertown Square terminal to encourage people to bike and ride public transit.

4.4.2 Install Bike Signs

There is a high incidence of bicyclists injuries along Route 20 in Watertown and Waltham. On-street parking and the high traffic volumes make it difficult for bicyclists to ride along with the vehicle traffic. To improve safety for bicyclists we recommend that appropriate signs be installed along Route 20 to increase motorists' awareness and cooperation with bicycle traffic.

4.4.3 Integration of Bicycle Transportation

The MDC will begin construction of new trails along the Charles River between Galen Street in Watertown and Elm Street in Waltham this fall. Over the next decade, the MDC hopes to extend paths as far as the Newton Marriott Hotel, in Auburndale, along both sides of the Charles River.

Besides these improvements, we also recommend a study examining the feasibility of providing a continuous bike route between Waltham and Watertown to link the Charles River bicycle path. Such integration would provide access to the public transit systems in the two communities, as shown in Figure 3-9 in Chapter 3. Candidate streets in Watertown for this proposal include Waltham Street and Pleasant Street. The detailed evaluation should include space for reasonable bike accommodation, smooth paved surfaces for the bicycle lane, desirable sight distances measured from the bicycle lane, consistent treatment (signing and safety measures), and connection to a bikeway system. The design standards must comply with AASHTO and MUTCD policies.

The MassHighway benchmark for reasonable bike accommodation is to provide a continuous paved usable shoulder adjacent to the outside travel lane in each direction of the

roadway where bicycles are legally permitted. The desirable width of the outside travel lane plus the paved usable shoulder (curb lane) is at least 5.0 meters (plus 0.5-meter "guardrail" offset). When this width cannot be reasonable accommodated, the minimum width of the outside travel lane plus the paved usable shoulder is 4.5 meters (plus 0.5-meter offset). For roadways with traffic volumes of less than 2,000 average annual daily traffic, the minimum roadway widths as defined in Chapter 8 of the Highway Design Manual may be used to conform with bicycle accommodation.

5. PROPOSED STRATEGIES TO ADDRESS PROBLEMS IDENTIFIED IN BOSTON

5.1 NEW PROJECTS AND DEVELOPMENTS

The City of Boston has put forward two transportation projects (one awaiting funding and the other completed) that address some of the problems identified in this study. We have reviewed those projects and have incorporated them in the recommended strategies to address the transportation-related problems in the corridor. This study has also accounted for new developments coming into the corridor and their impacts. Brief descriptions of the City's transportation projects are given below and are followed by brief descriptions of the anticipated developments:

1. Commonwealth Avenue Road Reconstruction Project (Segment A/Phase 2)[10]

The Commonwealth Avenue Road Reconstruction Project (Segment A/Phase 2) in the City of Boston will address existing roadway safety and infrastructure deficiencies on Commonwealth Avenue. Improvements include street reconstruction, traffic safety and operational upgrades, and landscape amenities. The project covers the segment of Commonwealth Avenue extending between Beacon Street (Kenmore Square) and Brighton Avenue (Packard's Corner), approximately 7,200 feet in length. This project is not funded in the current Transportation Improvement Program and Air Quality Conformity Determination (FY 1998-2003). The City of Boston will be prepared to advertise this project in fiscal year 1998, if funding is secured. It is expected to be completed under the Surface Transportation Program (STP).

2. The Brighton Avenue Reconstruction Project[11]

The Brighton Avenue Reconstruction Project has recently been completed. It extends from Cambridge Street to Commonwealth Avenue in Brighton, approximately 3,700 feet. The City of Boston proposed this project to improve upon safety and traffic

[10] City of Boston, *Commonwealth Avenue-Segment 'A' Design Report*, Bruce Campbell & Associates, Inc., May 1997.

[11] City of Boston, *Urban Systems Project, Brighton Avenue Reconstruction Project*, Project Improvements Report, November 1994.

operations along Brighton Avenue. The project included the upgrading and installation of traffic signals, as needed, along Brighton Avenue. The improvements included four 11-foot lanes, two in each direction, with 10-foot left-turn lanes at major intersections, nine-foot-wide parallel parking stalls, and 10-foot-wide sidewalks on both sides of the roadway. The two traffic directions are separated by a 6-foot median (minimum), and wherever a 16-foot median is available, a raised planter for landscaping is provided. The existing signalized intersections were upgraded with new equipment. Also, the intersection of Brighton Avenue and Allston Street was signalized as a result of this project.

3. The Landmark Center (A Reuse Proposal for the Sears Building)[12]

The Sears Building parcel is bounded by Park Drive, Brookline Avenue, Fullerton Street, and the Green Line. This building is located about 2,000 feet from Kenmore Square (Route 20, Commonwealth Avenue). The newly renovated Landmark Center will consist of 602,000 square feet of office space, 171,000 square feet of retail space, a 67,000-square-foot cinema complex, a 27,000-square-foot health/sports center, and parking for 1,966 cars. Construction was scheduled to begin in the summer of 1998 and occupancy planned for the fall of 1999. The Reuse plan will provide 4,000 office jobs and 600 retail jobs. That study's traffic impact analyses indicate little impact on Kenmore Square.

4. The Institutional Master Plan for Boston University - Charles River Campus[13]

The Master Plan development objectives for Boston University over the ten-year period beginning in 1996 include the completion of existing projects, improvements to the visual appearance and livability of the campus, and the addition of some new recreational, teaching, residential, and research facilities. Probable university development projects in the Master Plan, subject to availability of funding and research needs, are:

Armory Housing Phase 1: Approximately 720 units of student housing are planned for the Armory site at the corner of Buick Street and the Massachusetts Turnpike.

Bay State Road Mall: Redesign Bay State Road and develop plans to restrict traffic in certain areas in order to enhance landscaping and allow for the use of appropriate urban design paving materials such as bricks and concrete.

[12] *The Landmark Center, A Reuse Proposal for the Sears Building, Draft Project Impact Report/Draft Environmental Impact Report*, the ABBEY Group, Boston, MA, December 1996.

[13] *Boston University Institutional Master Plan 1996-2000, Plan Notification Form*, the Trustees of Boston University.

Expanded Athlete Facilities: Studies are underway to determine the feasibility of expanding the Case Center or developing facilities at 300 Babcock Street. If funding is secured, the planned arena on the Armory site would proceed. The University also plans to develop a new physical education facility on campus.

Classroom Building Behind the College of Liberal Arts: A low-level structure is being considered over the parking behind 725 Commonwealth Avenue, possibly incorporating a promenade spanning Storrow Drive which would connect the campus with the Charles River.

Expanded Facilities for Central Library and School of Law: A relocation or expansion of the library facilities will be required in the coming decade. The School of Law adjacent to the Mugar Memorial Library also requires new facilities.

Additional Instructional and Research Laboratories: Due to a shift towards science and growth in the University-sponsored research programs, additional laboratory space will be required in the central campus area.

Because of the relatively conceptual nature of much of the Master Plan, our study did not attempt to estimate the future traffic growth that could result from these developments. However, the Commonwealth Avenue Road Reconstruction Project (Segment A/Phase 2) considered future traffic growth in this area.

5.2 STRATEGIES TO ADDRESS ARTERIAL AND INTERSECTION-RELATED PROBLEMS

Because the City's two transportation projects mentioned at the beginning of this chapter address some of the problems identified in the Boston area, we have divided Route 20 into four segments to allow us to account for these projects systematically:

Segment 1: Commonwealth Avenue from Arlington Street to Kenmore Square.

Segment 2: Commonwealth Avenue from Beacon Street (Kenmore Square) to Brighton Avenue (Packard's Corner).

Segment 3: Brighton Avenue from Commonwealth Avenue to Cambridge Street.

Segment 4: North Beacon Street from Cambridge Street to Birmingham Parkway.

5.2.1 Intersection Traffic Delays

All the traffic signals on Commonwealth Avenue and Brighton Avenue portions of Route 20 in Boston are coordinated and operated through the Boston Transportation Department's

(BTD) Traffic Control Center. The traffic signals on North Beacon Street in Brighton are not part of the BTD traffic control system. Chapter 2 of this report describes the problems, equipment status, and mode of operation at each of the critical intersections (operating at LOS E or worse).

Most of the traffic signals in the system are operated under a semi-actuated, coordinated mode. Under this mode, the main-street phases have maximum recall and show maximum green times while the side-street phases may be actuated, gap-out early, or skipped entirely. Any unused time is transferred to the main-street phases. At Harvard and Cambridge streets, the signals operate under a fully actuated-coordinated mode where all the signal phases are actuated but have no maximum recall. Phases can gap-out early or be skipped entirely.

Traffic signals on Commonwealth Avenue and Brighton Avenue operate under a common cycle length (100 and 110 seconds for the a.m. and p.m. periods, respectively). This common cycle length is required to provide coordination along the arterial. Pedestrian signal indications and push-buttons are provided at each intersection along Commonwealth Avenue and Brighton Avenue. The following sections describe the proposed improvements, taking into consideration the two City of Boston transportation projects:

Segment 1: Commonwealth Avenue from Arlington Street to Kenmore Square

Presently, no transportation project has been formally proposed for this segment of Commonwealth Avenue. All the signals within this segment are coordinated and operate efficiently except at the intersections of Charlesgate East and Beacon Street/Brookline Avenue (Kenmore Square). These two intersections experience excessive signal delays during the peak periods.

Commonwealth Avenue @ Charlesgate East

At Charlesgate East and Commonwealth Avenue, the eastbound and northbound traffic from the Bolyston ramp and Charlesgate East, respectively, experience excessive traffic delays, operating at LOS F during the peak periods. Proposed improvements at this intersection are minor and consist of retiming the traffic signal to proportionally allocate the green times to reduce traffic delays. No geometric improvements or updating of signal equipment is proposed. The existing cycle length is retained for the purpose of coordinating the signals (100 seconds for the a.m. period and 110 seconds for the p.m. period). With these timing improvements, all the approaches at this intersection should operate at LOS D or better. See Appendix D for comparison of existing and proposed signal timing and offsets.

Commonwealth Avenue @ Kenmore Square

The Kenmore Square intersection operates at capacity during the peak periods due to high traffic and pedestrian volumes. All approaching streets to this intersection (Commonwealth Avenue, Beacon Street, and Brookline Avenue) operate at LOS E or worse. To improve safety

and traffic operations, we recommend that the existing phasing plan be modified slightly. A lagging protected phase of about 8 seconds is proposed for Brookline Avenue traffic, as shown in Figure 5-1, to reduce traffic delay and also help bus operations on Brookline Avenue. During this overlap phase, traffic westbound on Commonwealth Avenue/Beacon Street would move, thereby increasing the intersection traffic capacity and throughput. With this improvement, all approaches would operate at LOS E or better. While these improvements would reduce the overall traffic delay, they would decrease the progression band for Commonwealth Avenue slightly. The estimated results of the improvements are summarized in Table 5-1.

The signal timing improvements at Kenmore Square provide only a short-term solution. Some approaches operate near capacity with little or no room to handle more traffic. Presently, there is no space at Kenmore Square for geometric improvements such as adding lanes, and the signal timing improvements will not be able to address special- event traffic generators such as the Fenway Park baseball games. Traffic can be expected to grow at Kenmore Square, considering the Boston University development projects and the proposed Sears Landmark Building. Long-term strategies may be required to alleviate traffic congestion at Kenmore Square.

TABLE 5-1

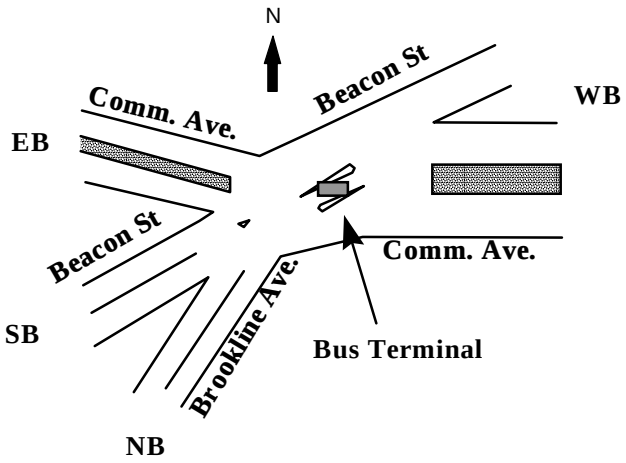
Approach Delays and Levels of Service Estimated to Result from the Proposed Improvements at the Charlesgate East and Kenmore Square Intersections

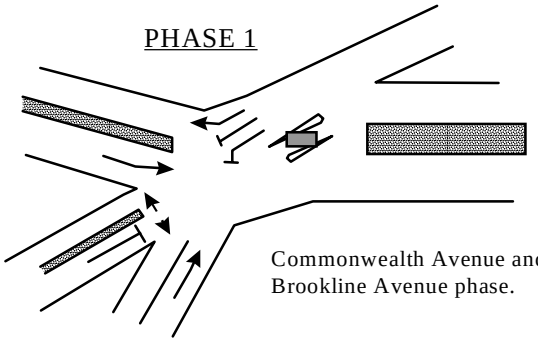
		Approach Delay and Level of Service (sec/veh)			
INTERSECTION	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
Commonwealth Avenue @ Charlesgate East (South Roadway) [Boylston ramp approach is represented as southbound]	AM	9 (B)	-	27 (D)	23 (C)
	PM	15 (C)	-	30 (D)	31 (D)
Commonwealth Avenue @ Charlesgate East (North Roadway)	AM	-	22 (C)	4 (A)	-
	PM	-	16 (C)	14 (B)	-
Commonwealth Avenue @ Kenmore Street	AM	39 (D)	-	22 (C)	-
	PM	14 (B)	-	30 (D)	-
Commonwealth Avenue @ Brookline Avenue (Brookline Avenue is represented as northbound and Beacon Street as southbound)	AM	33 (D)	17 (C)	51 (E)	44 (D)
	PM	30 (D)	15 (C)	30 (D)	34 (D)

Note: These estimates were made using the Highway Capacity Software

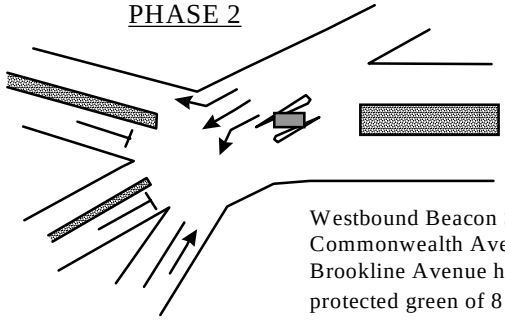
FIGURE 5-1

Proposed Traffic Phasing Pattern for Kenmore Square in Boston

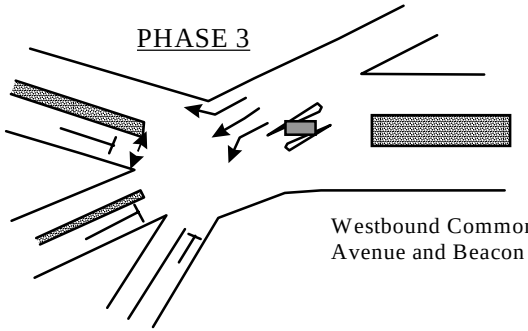




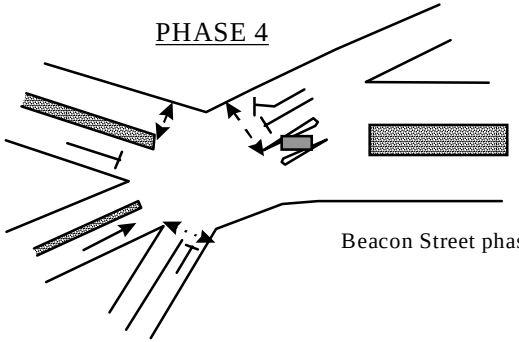
Commonwealth Avenue and Brookline Avenue phase.



Westbound Beacon Street and Commonwealth Avenue phase. Brookline Avenue has an overlap protected green of 8 seconds.



Westbound Commonwealth Avenue and Beacon Street phase.



Beacon Street phase.

Segment 2: Commonwealth Avenue from Beacon Street to Brighton Avenue

This segment of Route 20 constitutes the project area of the proposed Commonwealth Avenue Road Reconstruction Project (Segment A). It has the B Branch of the MBTA Green Line trolley running in the median. All the traffic signals within this segment are interconnected and operated through the BTD computer traffic control center. Presently there are ten traffic signals in this segment, five of which experience excessive traffic delays (LOS E or worse) during the peak periods. Detailed descriptions of the traffic problems at the following five signalized intersections are provided in Chapter 2 of this report:

1. Commonwealth Avenue at University Road/Carlton Street.

2. Commonwealth Avenue at BU Bridge/Essex Street.

3. Commonwealth Avenue at Buick Street/St. Paul Street.

4. Commonwealth Avenue at Harry Agganis Way/Pleasant Street.

5. Commonwealth Avenue at Babcock Street.

The proposed Commonwealth Avenue Road Reconstruction Project (Segment A) includes several types of improvements: geometric and traffic signal retiming improvements, upgrading the traffic control and equipment to facilitate signal operations, and enhanced pedestrian indications and phases to reduce traffic signal delay in this area. Briefly, the traffic design improvements in the project are:

1. At St. Mary's, St. Paul, and Babcock streets, converting one of the three existing general-purpose lanes in the westbound direction to a designated exclusive left-turn lane. These improvements would generally not reduce the existing traffic capacity in the westbound direction but would greatly improve traffic safety.

2. Providing two general-purpose lanes in the eastbound direction to match the westbound, with exclusive left-turn lanes at Cummington Street and at one of the three major intersections west of the BU Bridge (Pleasant Street, St. Paul Street, or Babcock Street). These storage lanes for left-turning traffic would reduce conflicts between automobiles and MBTA trolleys.

3. Improving turning radii at major intersecting streets and providing new pavement markings and signing to facilitate traffic operations.

With these improvements, all the intersections in the segment except Commonwealth Avenue at Buick Street/St. Paul Street and Commonwealth Avenue at H. Agannis Way/Pleasant Street are projected (year 2016) to have acceptable levels of service (LOS D or better).

As mentioned earlier, the Commonwealth Avenue Road Reconstruction Project (Segment A/Phase 2) was not included for funding in the current TIP. In the previous TIP, the City of Boston was prepared to advertise this project in the fiscal year 1997 or 1998 if funding was secured. Thus, the project may not go on as scheduled.

In the interim, we are recommending that the traffic signals in this segment be retimed to reduce signal delay on Commonwealth Avenue and its cross streets. Traffic signal coordination and other intersection improvements which reduce signal delay to the through traffic on Commonwealth Avenue would also improve MBTA trolley operations.

The PASSER-II 90 program was used to assess the benefits of signal coordination along Commonwealth Avenue. It must be emphasized that the existing geometric and lane configurations were used in this analysis without any modifications. Also, the common cycle for a.m. and p.m. peak periods (100 seconds for a.m. and 110 seconds for p.m.) were used to link this coordinated segment with other segments in the system. The resulting approach delays and levels of service are as shown in Table 5-2. Detail signal information including offsets and splits are provided in Appendix D. Through signal coordination, traffic delay can be reduced to acceptable levels.

At Packard's Corner (Commonwealth Avenue at Brighton Avenue), both field observations and intersection capacity analysis indicate acceptable levels of service for automobiles. However, our field delay studies indicate excessive delay for the Green Line trolleys. This intersection is included in the Commonwealth Avenue Road Reconstruction Project (Segment B), and we recommend installation of trolley priority systems to improve the Green Line B Branch operations.

Segment 3: Brighton Avenue (from Commonwealth Avenue to Cambridge Street)

The Brighton Avenue Reconstruction Project improved traffic safety and operations along Brighton Avenue. All the signalized intersections within this segment were upgraded, and left-turn bays were provided at major intersections. Presently both the signalized and unsignalized intersections within this segment operate well, without excessive delays, except for the Brighton Avenue and Harvard Street intersection. At this intersection, the southbound approach on Harvard Street experiences excessive traffic delay, LOS F during both peak periods. The remaining approaches operate at acceptable levels of service (LOS E or better).

We recommend signal retiming and reconfiguration of the lanes at both approaches on Harvard Street to improve traffic flow and also facilitate bus operations. The proposed timing improvements increase Harvard Street's green time to reduce side street delays. The intersection capacity analysis including phase patterns and times are provided in Appendix D. We recommend that both approaches on Harvard Street be restriped to provide storage bays for the left-turning traffic as shown in Figure 5-2. A left-turn storage bay of 100 feet (four car lengths) would be adequate. Providing storage bays for the left-turn vehicles would prevent them from blocking the through traffic, thereby increasing the intersection capacity.

TABLE 5-2

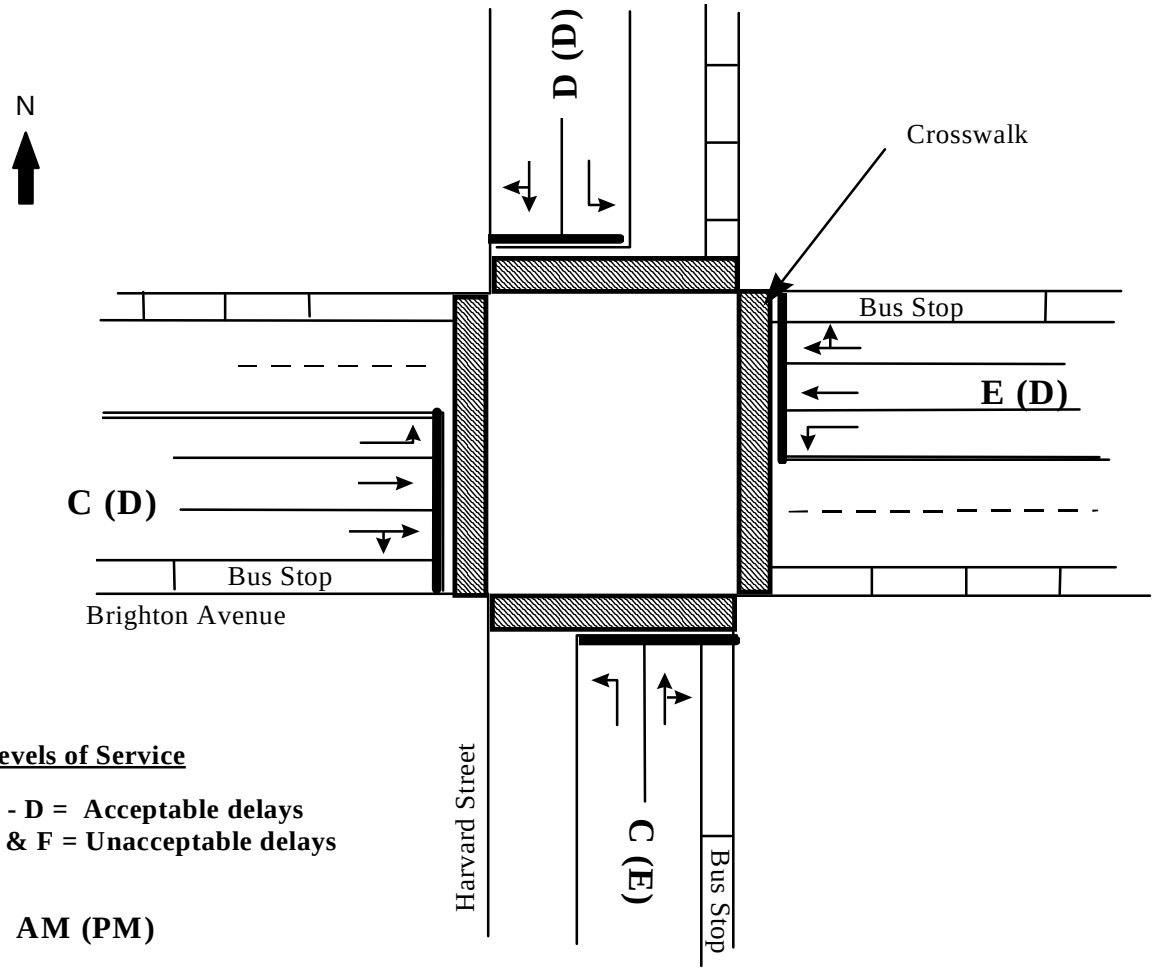
Approach Delays and Levels of Service Estimated to Result from Proposed Signal Coordination Along Commonwealth Avenue (from Blandford and Sherborn Streets to Babcock Street)

		Approach Delay and Level of Service* (sec/veh)			
INTERSECTION	**Peak Hour**	**EB**	**WB**	**NB**	**SB**
Commonwealth Avenue @ Blandford Street/Sherborn Street	AM	3 (A)	3 (A)	23 (C)	26 (D)
	PM	9 (B)	4 (A)	31 (D)	51 (E)
Commonwealth Avenue @ Granby Street	AM	1 (A)	3 (A)	_	22 (C)
	PM	2 (A)	9 (B)	_	30 (D)
Commonwealth Avenue @ Cummington Street	AM	3 (A)	1 (A)	25 (C)	_
	PM	6 (B)	1 (A)	41 (E)	_
Commonwealth Avenue @ St. Marys Street	AM	3 (A)	3 (A)	_	_
	PM	11 (B)	5 (A)	_	_
Commonwealth Avenue @ University Street/Carlton Street	AM	4 (A)	14 (B)	14 (B)	8 (B)
	PM	10 (B)	28 (D)	22 (C)	58 (E)
Commonwealth Avenue @ Essex Street/BU Bridge	AM	9 (B)	9 (B)	15 (C)	22 (C)
	PM	16 (C)	52 (E)	13 (B)	70 (F)
Commonwealth Avenue @ Amory Street	AM	4 (A)	1 (A)	32 (D)	_
	PM	3 (A)	1 (A)	37 (D)	_
Commonwealth Avenue @ Buick Street/St Paul Street	AM	69 (F)	29 (D)	99 (F)	19 (C)
	PM	56 (E)	29 (D)	32 (D)	87 (F)
Commonwealth Avenue @ H. Agganis Way/Pleasant Street	AM	5 (A)	3 (A)	29 (D)	23 (C)
	PM	49 (E)	3 (A)	40 (E)	29 (D)
Commonwealth Avenue @ Babcock Street	AM	19 (C)	8 (B)	22 (C)	19 (C)
	PM	31 (D)	13 (B)	26 (D)	30 (D)

*Results obtained using the program PASSER II-90.

FIGURE 5-2

Proposed Improvements at the Intersection of Brighton Avenue and Harvard Street in Boston with Estimated Levels of Service



This recommendation may require moving the bus stop at the northbound approach on Harvard Street further back so that Route 66 buses can easily make the transition into the left-turn bay to turn onto Brighton Avenue. At the southbound approach, on-street parking would have to be removed from the inbound approach (about four car lengths) to make room for the left-turn bay as shown in Figure 5-2. With these improvements, all the approaches would operate at LOS E or better. It must be noted that the common cycle length would be preserved to enable signal coordination along Brighton Avenue. While this improvement would reduce delay on Harvard Street, it would slightly reduce the green progression band on Brighton Avenue.

Segment 4: North Beacon Street (from Everett Street to Birmingham Parkway)

Presently, no transportation project has been formally proposed for this segment of Route 20. There are three signalized intersections within this segment: Everett Street, Etna Street/Life Street, and Market Street traffic signals. There were no traffic problems at the intersection of North Beacon Street and Etna Street/Life Street. None of these traffic signals is connected to the BTD computerized control center.

North Beacon Street @ Everett Street

The Everett Street intersection was improved as part of the Brighton Avenue Reconstruction Project: minor geometric improvements were made as it was assumed that the level of service is acceptable. We recommend that this signal be connected to the BTD computerized traffic control system because of its close proximity to the Brighton Avenue and Cambridge Street intersection. Connecting the Everett Street signal to the BTD system and coordinating it with the other signals would improve traffic operations at the Everett Street signal. We also recommend removing the on-street parking at the westbound approach on North Beacon Street. This causes severe traffic disruptions at the intersections of North Beacon Street with Cambridge Street and Everett Street.

North Beacon Street @ Market Street

At the intersection of North Beacon Street and Market Street, the existing two-phase plan results in significant delays (LOS E) for the northbound and westbound approaches during both peak periods. To improve traffic operations at this intersection, we are proposing that the traffic signal be retimed to allocate the green times proportionally. Also, the signal equipment should be upgraded and actuated traffic control provided at this intersection to utilize the green times effectively.

We also recommend that the post-mounted signal on both approaches on North Beacon Street be replaced with overhead signals. Overhead signals interfere much less with motorists' sight-lines and can be seen from farther away from the intersection than post-mounted signals. Currently, at both approaches on North Beacon Street, traffic operates in two streams (a left-turn traffic stream and a through-plus-right-turn traffic stream). We recommend that both approaches on North Beacon Street be formally striped to accommodate a left-turn storage bay and a

through-plus-right-turn lane, as shown in Figure 5-3. The existing pavement width will allow for this geometric improvement without any land-taking.

5.2.2 Strategies to Address Illegal and Double-Parking

There are four locations along Route 20 in the Boston area where illegal and double-parking affect the safety of motorists and bicyclists. Illegal parking causes bottlenecks that reduce the roadway capacity and disrupt traffic flow. Detailed descriptions of the illegal parking problems are presented in Chapter 2 of this report in the section on on-street parking.

Commonwealth Avenue from Arlington Street to Massachusetts Avenue

This segment of Commonwealth Avenue is mostly residential, with apartment buildings predominating. Insufficient off-street parking for residents and the absence of loading and delivery areas has resulted in a high rate of double-parking in this area. On most occasions, double-parking reduces the two travel lanes to one in both directions on Commonwealth Avenue, causing traffic congestion during the peak periods and imperiling the safety of bicyclists. The signs installed in this neighborhood permit only residential on-street parking and prohibit any other uses.

Considering the importance of on-street parking, delivery, and loading services in this area, we are proposing the following measures to improve traffic operations and also serve the community's parking needs.

1. Provide enforcement to prevent double-parking.

2. Create areas to serve the high rate of maintenance and delivery services, for example encourage deliveries from alleys.

Kenmore Square in Boston

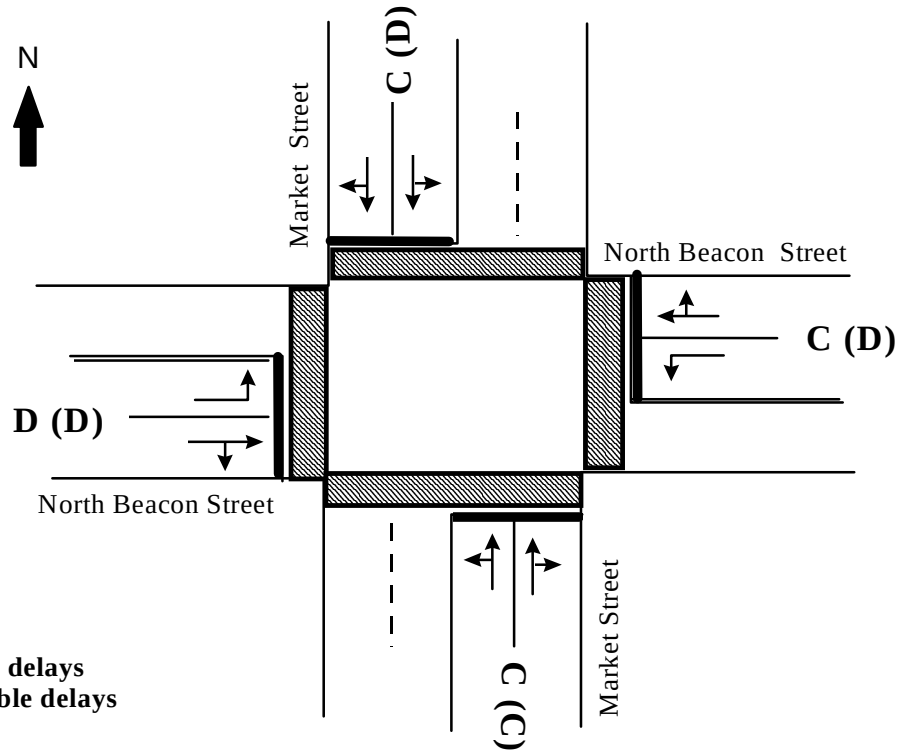
Kenmore Square commercial activities generate high volumes of short-term parking. The vehicular and pedestrian traffic, both with high volumes at this congested intersection, is severely affected when double-parking takes any of the travel lanes away. The following measures are recommended for addressing the double-parking problem at Kenmore Square:

1. Provide enforcement at this location sufficient to substantially reduce illegal and double parking.

2. Improve signing to direct motorists to surrounding off-street parking.

FIGURE 5-3

Proposed Improvements at the Intersection of North Beacon Street and Market Street in Boston with Estimated Levels of Service



Levels of Service

A - D = Acceptable delays
E & F = Unacceptable delays

AM (PM)

Commonwealth Avenue from Sherborn Street to Packard's Corner

As documented in Chapter 2 of this report, Boston University and commercial activities in this area generate on-street parking with high turnover rates. Motorists park close to intersections, reducing sight distances for both pedestrians and motorists. They double-park in both directions along Commonwealth Avenue, reducing the roadway capacity and affecting safety for bicyclists.

The Commonwealth Avenue Road Reconstruction Project (Segment A) includes several measures addressing the illegal and double-parking along this segment of Commonwealth Avenue, and we support those recommendations. Some of these measures can be implemented now, while others can only be incorporated during the construction phase. Measures recommended by the Segment A project that can be implemented independently to reduce the double- and illegal parking include:

1. Creating two drop-off areas, one in front of Marsh Chapel and the other in front of Warren Towers, to address the extremely high turnover rate.

2. Removing parking meters located very close to intersections to improve sight distances including giving a clear view of the pedestrian crosswalks.

3. Provide enforcement to minimize double-parking.

Among the measures that can not be implemented independently but have to be part of the Segment A reconstruction project is the installation of pedestrian chokes (extension of the sidewalks at intersections) to reduce crossing distance and facilitate pedestrian crossing, as well as prevent parking close to intersections.

North Beacon Street at Brighton Avenue and Cambridge Street (Union Square).

Illegal parking at the outbound approach on North Beacon Street forces two lanes of westbound straight-through traffic from Brighton Avenue to squeeze into one lane at this location. This bottleneck causes the westbound straight-through traffic to queue as it funnels into a single lane, blocking the intersection. During peak periods this blockage prevents traffic on Cambridge Street from moving even when it has the green light. This problem is well documented in Chapter 2 of this report in the section on on-street parking. We are recommending the following measures to address this illegal parking problem:

1. Provide yellow curb markings that prohibit parking at this location. The intended meaning should also be stenciled on the curb.

2. Because snow and ice frequently obliterate curb markings, install a parking prohibition sign, "NO PARKING ANY TIME" (R7-1).

3. Provide enforcement at this location to ensure compliance.

5.3 STRATEGIES TO ADDRESS TRANSIT-RELATED PROBLEMS

The public transit system serving the Route 20 corridor in the Boston area includes bus service and light rail. The major bus routes serving the Boston area are Route 57 (Watertown Square-Kenmore Station), Route 64 (Oak Square-Central Square, Cambridge), and Route 66 (Harvard Square-Dudley Station). The B Branch of the Green Line runs in the median of Commonwealth Avenue from Brighton Avenue (Packard's Corner) to Blandford Street.

There are several transit-related problems in the Route 20 corridor in the Boston area. Bus operation concerns include passenger crowding, schedule adherence, and traffic congestion affecting the navigation of bus routes. On the Green Line some of the problems are permitted left-turn and U-turn traffic conflicts, passenger crowding, and schedule adherence. These problems have been documented in Chapter 2.

5.3.1 Bus Transit Strategies

Bus transit strategies for addressing the identified problems are categorized into traffic management strategies and operations strategies. Traffic management strategies address traffic problems for buses at intersections and the placement of bus stops at intersections. Operations strategies address problems with scheduling, crowding, transfers, and route layout to bring the transit services into compliance with the MBTA Service Quality Standards as defined in the Service Delivery Policy and into compatibility with the objectives of the Congestion Management System.

Traffic Management Strategies to Address Bus Service Problems

Bus routes passing through transfer points at Kenmore Square in Boston and Union Square in Brighton on Route 20 suffer from difficult intersection geometrics and congested traffic conditions. Access to the Kenmore Square terminal for buses on Brookline Avenue is particularly difficult.

Access to Kenmore Square Bus Terminal

This terminal, located in the middle of Kenmore Square, also serves as a pedestrian portal to the Green Line Central Subway system, and generates high pedestrian and bus traffic volumes. Access for buses from Brookline Avenue is difficult, and the flow of traffic through the intersection is high. Because the eastbound traffic on Commonwealth Avenue and Brookline Avenue share a common traffic signal phase (i.e., traffic on both streets moves at the same time) buses from Brookline Avenue have to weave through three traffic lanes on Commonwealth Avenue to enter the station. Presently the Kenmore Square intersection operates at a failing level of service (LOS F). Our analysis indicates that separating the Brookline Avenue phase entirely from that of Commonwealth Avenue results in additional delay for this intersection, worsening

the existing condition. The high levels of pedestrian activity at Kenmore Square and the high traffic volumes justify the exclusive pedestrian phases at this intersection.

We recommend modifying the existing phasing pattern slightly to provide an optimal phasing that reduces traffic delay, provides for safe pedestrian crossing, and give buses easy access to Kenmore Square. The traffic signal should be retimed to reapportion the green time to the signal phases. A lagging, protected, overlap phase should be provided for Brookline Avenue traffic to improve the overall level of service from failing to LOS E or better.

This lagging, protected, overlap phase for Brookline Avenue traffic is provided by splitting the shared Commonwealth Avenue and Brookline traffic phase. During this lagging, protected phase for Brookline Avenue eastbound traffic, Commonwealth Avenue westbound traffic should proceed onto Beacon Street and Brookline Avenue – i.e., maximizing the intersection throughput. Under this plan, no U-turns are allowed at the westbound approach. The recommended phasing plan is shown in Figure 5-1. Although this phasing plan does not provide a separate protected phase for the buses on Brookline Avenue, it increases the time available for the traffic from Brookline Avenue trapped in the flow of traffic from Commonwealth Avenue to clear the intersection. This plan will also allow more time for buses to merge and weave across Commonwealth Avenue to enter the bus terminal.

Bus Navigation at Union Square

In 1996, the City of Boston initiated the Brighton Avenue Reconstruction Project, which resulted in a redesign of Union Square. This redesign has resulted in significant operational difficulties for the MBTA and inconvenience to its passengers. Also, illegal parking in the departure lanes on North Beacon Street forces two lanes of westbound traffic to squeeze into one lane, as discussed in Chapter 2, Section 2.2.5, of this report. Relocation of bus stops has made transfers more difficult for many of the transferring passengers (most of whom transfer between bus Routes 57 and 66).

We recommend that the stop line on the Cambridge Street southbound approach be moved further back to make it easier for buses to turn left onto Brighton Avenue eastbound. Another potential alternative to address this problem would be the rerouting of Route 66 to stay on Harvard Street, both northbound and southbound. This would eliminate the difficult left-turn maneuver, but would inconvenience passengers who board at Brighton Avenue and Cambridge Street .

We also recommend that illegal parking in the westbound departure lanes on North Beacon Street be eliminated with strict enforcement. A study of the area could reveal appropriate sites for off-street parking to replace any lost on-street parking spaces. This measure would further reduce congestion by restoring the use of the second traffic lane and reducing the chances of Route 64 buses getting trapped in the intersection due to merging traffic.

Traffic Signal Delays Affecting Bus Transit Service

Traffic signal delay contributes to schedule adherence problems for MBTA buses. Route 57 buses travel over a large portion of Route 20 (Commonwealth Avenue and Brighton Avenue). Route 64 and 66 buses travel on Route 20 along North Beacon Street and Brighton Avenue in Brighton, respectively. As discussed in Chapter 2, Route 57 and 64 buses face several minutes of cumulative delay. Traffic analysis performed for Route 20 (Commonwealth Avenue, Brighton Avenue, and North Beacon Street) suggests traffic signal retiming and coordination strategies can benefit bus operations significantly.

The delay reductions for Commonwealth Avenue and Brighton Avenue improve travel conditions for Route 57 buses, which will benefit in terms of reduced passenger hours of delay. Route 57 will improve significantly since Commonwealth Avenue and Brighton Avenue are its most heavily patronized segments. Just a few minutes savings in travel time translate to generous reductions in passenger hours of delay. This is particularly true for the eastbound route in the a.m. peak and the westbound route in the p.m. peak, as shown in Table 5-3.

Judging by these results, we recommend that other portions of Routes 57 and 66 be studied, outside of the context of this Route 20 study, to determine whether traffic management improvements such as signal retiming and coordination can offer further time savings for the buses and assist with schedule adherence problems, while improving the comfort level for passengers on-board the buses.

Operations Strategies

Routes 57 and 66 have schedule adherence and passenger crowding problems. Both routes have high ridership and already have frequent service. Strategies to address the problems include increasing the frequency of service in the peak periods and minor rerouting to shorten travel times.

Schedule Adherence

To reduce the travel time on Route 66 and thereby address the schedule adherence problems, the MBTA has recommended routing its outbound bus trips through the Harvard Square bus terminal, as indicated in its Annual Service Plan. We recommend keeping the existing path for Route 66 and improving traffic operations at the intersections of Brighton Avenue with Harvard Street and Cambridge Street to help the Route 66 bus service. The plan includes improving the left turn to Brighton Avenue westbound from Harvard Street northbound. The intersection's present geometric layout provides a left-turn bay and two through lanes at both approaches on Brighton Avenue and a single lane at both approaches on Harvard Street. Because the northbound approach on Harvard Street is wide enough to accommodate two traffic lanes, drivers sometimes form a de facto left-turn lane from Harvard Street onto Brighton Avenue.

TABLE 5-3

Route 20 Cumulative Bus Passenger Hours of Delay

Scenario	Bus Route	Peak Hour	EB		WB	
			Delay/Trip Minutes	Pax Hrs Delay	Delay/Trip Minutes	Pax Hrs Delay
Existing Conditions	57	AM	5.5	40.3	2.1	5.3
		PM	7.6	17.0	3.5	18.1
	64	AM	3.5	3.3	2.0	0.4
		PM	1.3	0.4	2.8	2.3
With Traffic Improvements	57	AM	3.4	25.2	2.4	6.4
		PM	4.7	12.5	3.9	19.4
	64	AM	2.2	2.2	1.6	0.4
		PM	1.6	0.5	1.8	1.8

Note: The numbers are for bus paths that lie along the Route 20 arterial.

We recommend that both the northbound and southbound approaches be restriped to provide a left-turn bay and a lane for the through traffic plus right-turn traffic, as shown in Figure 5-2. Both the southbound and northbound approaches have sufficient width to accommodate these improvements. Furthermore, we are proposing that the signal be retimed and a protected traffic phase be provided for Harvard Street left turns. In retiming the signal, the common cycle lengths for signal coordination along Brighton Avenue during the a.m. and p.m. peak periods should be retained. To provide for smooth transition of the Route 66 buses into the left-turn bay, we recommend that the bus stop on Harvard Street at Brighton Avenue be moved back, far enough away from the intersection to allow the buses to change lanes after boarding passengers.

Passenger Crowding

Both Routes 57 and 66 have numerous weekday trips on which passengers stand for a large percentage of the trip in the peak periods. Although the average load factor of all the trips does not exceed the loading standard of 140% of seated capacity, numerous individual trips exceed the standard during the peak periods, as shown in Table 5-4. As a short-term strategy, we recommend increasing the frequency of trips scheduled during the morning and evening peak periods as shown in Table 5-5.

The MBTA's Annual Service Plan has recommended increasing frequencies for Routes 57 and 66. For Route 57, the final plan recommends increasing frequencies on Sundays from 30 minutes to 20 minutes during the early AM period (start of service-6:59 a.m.) and from 30 minutes to 15 minutes during the midday period. It also recommends improving Sunday frequencies between 9:45 a.m. and 12:45 p.m. On Saturdays, the plan recommends that the frequency of service for Route 57 be reduced from 7.5 minutes to 8.5 minutes between 3:25 p.m. and 5:40 p.m. due to excess capacity during this time period. For Route 66, the plan's proposal is to increase frequency during the AM peak period (7:00 a.m.-8:59 a.m.) from 10 minutes to 9 minutes during the weekdays. The proposed improvements are scheduled for implementation in the summer of 1998.

5.3.2 Green Line B Branch Strategies

As with the bus service, strategies for the Green Line fall into two categories: service quality and traffic management. Service quality issues have been evaluated in the context of the MBTA Service Delivery Policy. Traffic management issues are dealt with primarily in the context of the Green Line Signal Priority System. The Green Line's B Branch operates in the median of Route 20 (Commonwealth Avenue) between Packard's Corner (Brighton Avenue) and Blandford Street in Boston, where it enters the portal to the Central Subway. This stretch of Route 20 is the subject of a design report submitted to the City of Boston and MassHighway by Bruce Campbell and Associates, Inc.

TABLE 5-4

Passenger Crowding Characteristics for Bus Routes 57 and 66
(Calculated Using the Present 40-Seat Buses)

		Number of Trips, by Passenger Loading Level			
		Inbound		Outbound	
Bus Route	**Peak Period**	**> 100%**	**> 140%**	**> 100%**	**> 140%**
57	AM	18	7	4	2
	PM	2	0	9	1
66	AM	6	1	9	3
	PM	7	0	4	0

TABLE 5-5

Headway Recommendations for Routes 57 and 66

		Current (minutes)		Proposed (minutes)	
Bus Route	**Direction**	**AM Peak**	**PM Peak**	**AM Peak**	**PM Peak**
57	Inbound	6	7	4	6
	Outbound	9	6	6	5
66	Inbound	10	10	8	8
	Outbound	10	10	7	9

That design report has several recommendations for improving traffic operations and safety for vehicular, transit, pedestrian, and bicycle traffic. Briefly, the proposals include signal retiming, updating of the existing traffic signal equipment, and installation of new, state-of-the-art trolley signal priority system hardware. Recommended measures include widening the MBTA right-of-way (reservation) and the installation of separate trolley signal controls at Pleasant Street/Harry Agganis Way and Cummington Street. Pedestrian and bicycle improvements involve the addition of a bicycle lane in each direction and provision of chokes (extension of the sidewalk and MBTA reservation) at intersections to accommodate large volumes of pedestrians and also facilitate pedestrian crossing.

Additional analyses were performed as part of this study to examine the feasibility, benefits, and overall impact of providing improved trolley signal priority. Service quality issues such as passenger loading, frequency and reliability of service, and schedule adherence are also addressed as part of the improvements. The Commonwealth Avenue Road Reconstruction Project (Segment A) does not modify existing MBTA station platforms to take full advantage of the trolley priority system nor does it determine the exact level of priority that can be provided at each signalized intersection. This study has addressed these issues.

LRT Signal Priority System and Traffic Signal Delay Reduction

Traffic congestion and traffic signals cause significant delay for Green Line transit service. A trolley priority system is a candidate strategy to improve transit and traffic operations along Commonwealth Avenue. The main concern with trolley priority systems is that the overall traffic performance may be compromised when optimal signal timings for vehicular traffic flow are overriden to provide travel advantage to transit vehicles. The TRAF-NETSIM simulation model was used to evaluate the impact of a trolley priority system on both vehicular and trolley traffic.

TRAF-NETSIM Model

TRAF-NETSIM[14] is the acronym for TRAFfic NETwork SIMulator. TRAF-NETSIM, a microscopic simulation model developed by the Federal Highway Administration (FHWA), is one of the few traffic models with some flexibility to model the operations and impact of both vehicular traffic and surface LRT service. Using TRAF-NETSIM for LRT simulation is not new; it has been used alone or in combination with other traffic programs to evaluate several LRT projects.[15, 16, 17] Research on the use of TRAF-NETSIM to evaluate LRT operations indicates that

[14] *TRAF User Reference Guide Version 4.0*, USDOT, FHWA, Office of Safety and Traffic Operations R&D, IVHS Research Division (HSR-11), McLean, Virginia, April 1993.

[15] P. Luedtke, S. Smith, H. Lieu, and A. Kanaan, "Simulating DART's North Central Light Rail Line Using TRAF-NETSIM," in 63rd Annual Meeting Compendium of Technical Papers, Institute of Transportation Engineers, Washington, D.C., September 1993, pp. 60-64.

the model produces moderately accurate estimates of field stopped delay. There are other programs designed specifically for modeling LRT operations and impacts: TransSim II[18] and VISSIM.[19] Neither of these models has been widely used and tested to evaluate LRT facilities in the U.S., and they are not available at CTPS.

TRAF-NETSIM Data Input

Green Line B Branch operation was modeled in TRAF-NETSIM with the ten traffic signals included in the Commonwealth Avenue Road Reconstruction Project (Segment A) design report. TRAF-NETSIM requires extensive input data. Coding the modeled environment required data describing the physical features and geometry of the roadway and transit line, travel data in terms of traffic and pedestrian volumes, turning movements, control devices and strategies, and data on the LRT operations. Special cards containing information on each characteristic of the modeled environment are used to input the data.

The transit line, streets, and intersections are represented as a network consisting of nodes and unidirectional links. The control devices required by TRAF-NETSIM include the intersection control (traffic signals, yield signs, and stop signs). The control strategies required are signal timing information and priority rules governing traffic operations. The data on LRT vehicle characteristics and operations that are needed include headways, dwell times, locations of stations, and operating speeds.

PASSER II-90 was first used to find the offsets and splits for signal coordination along Commonwealth Avenue. The offsets and splits along with the turning movements were used in TRAF-NETSIM. It must be noted that the offsets were slightly adjusted in TRAF-NETSIM to achieve progression and reduce queue build-up at certain intersections. Mean dwell times for each of the Green Line B Branch stations and mean headways were obtained via a field survey. It must be emphasized that the observed headways are for the surface LRT operations and do not include the bunching which occurs in the tunnel at Kenmore Square as a result of the merging traffic of the B, C, and D lines. The locations of and distances between the station platforms were obtained from existing plans. Some model default values were used for factors that are very difficult to measure in the field, including platoon dispersion, arrival distributions, and

[16] B. Rymer, J. C. Cline, and T. Urbanik, *Delay at Isolated Light Rail Transit Grade Crossings*, Texas Transportation Institute Report 339-10, Texas State Department of Highways and Public Transportation, Austin, Texas, 1987.

[17] S. P. Venglar, D. Fambro, and T. Bauer, *Validation of Simulation Software for Modeling Light Rail Transit*, Transportation Research Record 1494, Transportation Research Board, National Research Council, Washington, D.C., 1995.

[18] *TransSim II Data Input Instructions*, JRH Transportation Engineering, Eugene, Oregon, 1993.

[19] VISSIM Simulation Software, Integrated Transportation Concepts, Suite 101, 2380 NW Kings Boulevard, Corvaliss, Oregon.

acceleration and deceleration characteristics of the vehicles. Some of the assumptions used in the analysis were:

1. Maximum speed of 20 mph for the Green Line B Branch trolleys.

2. Free-flow speed of 30 mph for cars on Commonwealth Avenue (same as the speed limit).

3. Start-up lost time of 2 seconds at signalized intersections for automobiles.

4. Mean time gap of 2 seconds between vehicles for automobiles.

5. Average vehicle occupancy of 1.1 for converting vehicle hours of delay to person hours of delay.

Priority Levels

There are three types of trolley signal priority:

1. Full priority: where two-way communication between the light rail vehicles and the signal controllers allows the signal controllers to optimize signal timing (skipping phase(s), altering phase sequences, and/or changing the length of phases) to minimize delay for light rail. Controllers also have the capability to return to coordination in the absence of light rail vehicle calls.

2. Partial priority: where the light rail vehicles operate under a fixed-time signal controller logic at the intersections based on a signal timing plan that balances progression for the automobiles and light rail transit, but the light rail vehicles can extend their green window by early termination of the previous green ("early green") or later termination of the their own phase ("green extension").

3. Passive priority: where the light rail vehicles operate under a fixed-time signal controller logic at the intersections based on a signal timing plan that balances progression for the automobiles and light rail transit.

Only full priority and passive priority were modeled in this study. In modeling full priority, TRAF-NETSIM was not able to model or reproduce the real complex logic for signal control strategies, and the ability to constantly send information from LRT detection to multiple controllers to update LRT arrival times and cancel calls could not be analyzed. This capability of modern signal controllers provides efficient service that would lead to lower delays than those projected by our analysis. We were not able to model partial priority scenarios because the queue clearance thresholds for both arterial and cross streets involve complex switching and phase skipping logic that was beyond our modeling capabilities.

Tested Scenarios

The Green Line station platforms are located in close proximity to the intersections. A "near-side" station is one located just prior to an intersection relative to the direction of travel of the Green Line trolley. A far-side station is one located just after an intersection. Westbound, all but two of the stations are far-side stations; the platforms at Blandford Street and Cummington Street are near-side platforms. Eastbound, all but two of the stations are near-side; the platforms at Amory Street and Blandford Street are far-side platforms.

Far-side stations facilitate the operations of a trolley priority system. With far-side stations, when the LRT detection calls are registered, green extensions or early greens are provided to enable the trolleys to pass through the intersections to dwell at the far-side stations. On the other hand, near-side stations do not facilitate trolley priority systems, as the trolleys have to stop and dwell at the near-side stations before passing through the intersection. TRAF-NETSIM was used to test five scenarios:

1. The existing condition, where both the Green Line trolleys and automobiles operate under coordinated signals without any LRT detection or signal priority.

2. The Green Line trolleys operate under LRT detection and traffic signal priority with the existing lane configuration and existing station platform locations.

3. The Green Line trolleys operate under LRT detection and signal priority with the proposed lane configuration of the Commonwealth Avenue Road Reconstruction Project (Segment A) and existing station platform locations.

4. The Green Line trolleys operate under LRT detection and signal priority with the existing lane configuration and relocation of near-side stations to the far side.

5. The Green Line trolleys operate under LRT detection and signal priority with the proposed lane configuration of the Commonwealth Avenue Road Reconstruction Project (Segment A) and relocation near-side stations to the far side.

It must be emphasized that **Scenarios 2 and 3 are hybrid situations** in that they combine results from two different scenarios. Under Scenario 2, although signal priority is generally provided, it is not provided at intersection approaches with near-side stations; at those approaches, the LRT delays are the same as those under the existing condition, where no priority is provided. The same technique was applied for Scenario 3. By comparing Scenario 2 and Scenario 4, or Scenario 3 and Scenario 5, one can estimate the benefits to be gained from relocating near-side stations to the far side of intersections. This was done because it is difficult to provide priority at near-side stations in practice.

Model Results

The TRAF-NETSIM simulation results are shown in Table 5-6 for the Green Line B Branch trolleys. Based on our simulation results, full priority can be provided to trolleys at the intersections east of University Road/Carlton Street during peak periods without excessive adverse impact on the side street traffic delays. These are the intersections of Commonwealth Avenue with Blandford Street/Sherborn Street, Granby Street, Cummington Street, and St. Mary's Street. It must be noted that the trolley signal priority system increases the side street delays but that the levels of service are within acceptable limits.

Full priority for trolleys can not be provided during the peak periods without excessive adverse effects on the side streets at the following intersections of Commonwealth Avenue: University Road/Carlton Street, BU Bridge/Essex Street, Buick Street/St. Paul Street, H. Agganis Way/Pleasant Street, and Babcock Street. These intersections have higher traffic volumes on the side street compared with those east of University Road/Carlton Street. A trolley signal priority system would result in poor levels of service for the side street traffic (LOS E or worse). The estimated signal delay for both trolleys and automobiles is summarized in Appendix E of this report.

As shown in Table 5-6, with the existing station platform locations and lane configurations, the savings in signal delay for trolleys for both peak hours ranges from 10 to 27 seconds for the inbound direction and 8 to 29 seconds for the outbound direction. By relocating near-side stations to the far-side of intersections (only those intersections where full priority was recommended) to benefit from trolley signal priority, total savings in signal delay ranging from 27 to 43 seconds and 25 to 34 seconds can be realized for the inbound and outbound directions, respectively. Our analysis indicated no significant differences in signal delay resulting from the existing and proposed lane configurations.

In estimating person hours of delay, an average vehicle occupancy of 1.1 was assumed for the vehicular traffic on Commonwealth Avenue. The savings in person hours of delay for both automobiles and trolleys are given in Table 5-7. As can be seen in Table 5-7, implementing a trolley priority system would reduce the person hours of delay faced by trolley passengers. The model predicted that the addition of a trolley signal priority system, in conjunction with traffic signal coordination and optimization, would cut the total person hours of delay experienced by MBTA patrons by about 10% under Scenarios 2 and 3 (existing station platform locations). With relocation of near-side stations to the far side of intersections to benefit from signal priority, the total person hours of delay experienced by the MBTA patrons would be cut by about 20%.

We recommend that, where *possible and practical*, near-side stations at those intersections recommended for full trolley signal priority be relocated to the far side of intersections. Figure 5-4 shows the existing far-side and near-side station platforms.

Trolley signal priority also enhances the flow of Commonwealth Avenue through traffic: there is about a 1-2 percent reduction in automobile person hours of delay resulting from the

TABLE 5-6

Total Reduction in Signal Delay for Trolleys Estimated to Result from Trolley Signal Priority

		Eastbound (Inbound)		Westbound (Outbound)	
Scenario	**Peak Hour**	**Reduction in Signal Delay (seconds)**	**Existing Signal Delay (seconds)**	**Reduction in Signal Delay (seconds)**	**Existing Signal Delay (seconds)**
Scenario 2: Existing Lane Configurations and Existing Station Platforms with Trolley Priority	**AM**	10 (8%)	124	29 (23%)	126
	PM	27 (14%)	188	8 (6%)	134
Scenario 3: Proposed Lane Configurations and Existing Station Platforms with Trolley Priority	**AM**	3 (2%)	124	25 (20%)	126
	PM	22 (12%)	188	12 (9%)	134
Scenario 4: Existing Lane Configurations with Trolley Priority and Station Platforms at the Far Side	**AM**	27 (22%)	124	34 (27%)	126
	PM	43 (23%)	188	25 (20%)	134
Scenario 5: Proposed Lane Configurations with Trolley Priority and Station Platforms at the Far Side	**AM**	28 (23%)	124	36 (29%)	126
	PM	44 (23%)	188	25 (19%)	136

Note:

1. Values in parentheses are the percentage reduction in trolley signal delay.

2. Proposed lane configurations refer to the Commonwealth Avenue Road Reconstruction Project (Segment A).

3. Intersections where full trolley signal priority can be provided without excessive adverse effect on side street automobile traffic during the a.m. and p.m. peak hours:

1. *Commonwealth Avenue @ Blandford Street/Sherborn Street*
2. *Commonwealth Avenue @ Granby Street*
3. *Commonwealth Avenue @ Cummington Street*
4. *Commonwealth Avenue @ St Mary's Street*

4. Intersections where full trolley signal priority is not recommended because it can have an excessive adverse effect on side street automobile traffic during the a.m. and p.m. peak hours:

1. *Commonwealth Avenue @ University Road/Carlton Street*
2. *Commonwealth Avenue @ BU Bridge/Essex Street*
3. *Commonwealth Avenue @ Buick Street/St. Paul Street*
4. *Commonwealth Avenue @ H. Agganis Way/Pleasant Street*
5. *Commonwealth Avenue @ Babcock Street*

TABLE 5-7

Peak Hour Person Hours of Delay Savings Estimated to Result from Trolley Signal Priority System

		Reduction in Person Hours of Delay			
		Trolleys		Automobiles	
Scenario	**Peak Hour**	**Hours**	**(%)**	**Hours**	**(%)**
Scenario 2: Existing Lane Configurations and Existing Station Platforms with Trolley Priority	**AM**	10.6	12	2.4	1.4
	PM	10.5	10	3.8	1.8
Scenario 3: Proposed Lane Configurations and Existing Station Platforms with Trolley Priority	**AM**	4.8	5	2.6	1.5
	PM	12.0	11	3.8	1.8
Scenario 4: Existing Lane Configurations with Trolley Priority and Station Platforms at the Far Side	**AM**	20.5	23	1.2	1.0
	PM	22.5	21	4.1	2.0
Scenario 5: Proposed Lane Configurations with Trolley Priority and Station Platforms at the Far Side	**AM**	20.6	23	1.5	1.0
	PM	24.3	23	3.4	1.6

Note:

1. Proposed lane configurations refer to the Commonwealth Avenue Road Reconstruction Project (Segment A)

2. Intersections where full trolley signal priority can be provided without an adverse effect on automobile traffic during the a.m. and p.m. peak hours:

1. *Commonwealth Avenue @ Blandford Street/Sherborn Street*
2. *Commonwealth Avenue @ Granby Street*
3. *Commonwealth Avenue @ Cummington Street*
4. *Commonwealth Avenue @ St Mary's Street*

3. Intersections where full trolley signal priority is not recommended because it can have an adverse effect on automobile traffic during the a.m. and p.m. peak hours:

1. *Commonwealth Avenue @ University Road/Carlton Street*
2. *Commonwealth Avenue @ BU Bridge/Essex Street*
3. *Commonwealth Avenue @ Buick Street/St. Paul Street*
4. *Commonwealth Avenue @ H. Agganis Way/Pleasant Street*
5. *Commonwealth Avenue @ Babcock Street*

extra green time and coordination for the Commonwealth Avenue traffic. The side streets' signal delays, however, are increased, because of the priority given to the trolleys and Commonwealth Avenue through traffic. Table 5-7 shows the combined impact on Commonwealth Avenue and side street traffic. Detailed information on person hours of delay are provided in Appendix E of this report.

It must be emphasized that, while the trolley signal delays are balanced in both directions (inbound and outbound) during the a.m. and p.m. peak hours, the passenger loadings are not. During the a.m. peak hour the average passenger loadings for the inbound and outbound directions are 2057 and 510, respectively. During the p.m. peak hour the average passenger loadings for the inbound and outbound directions are 823 and 1676, respectively. These differences in passenger loading influence the person-hours of delay values shown in Table 5-7. Hence the large differences in person-hours of delay between the inbound and outbound directions for the same time period.

Information and Data Sharing

The MBTA is interested in the possibility of creating a communications connection between the Boston Transportation Department's Traffic Control Center and the MBTA Operations Control Center. It is envisioned that such a connection would provide real-time information regarding the location of light rail vehicles (LRVs) enabling the MBTA Operations Control Center to make changes in the operations of Green Line service in response to major events, incidents in traffic, and failures in service. As part of such a dual purpose system, it is possible that the Traffic Control Center facility would need modifications, an upgrade, or replacement.

MBTA Green Line Pedestrian Access

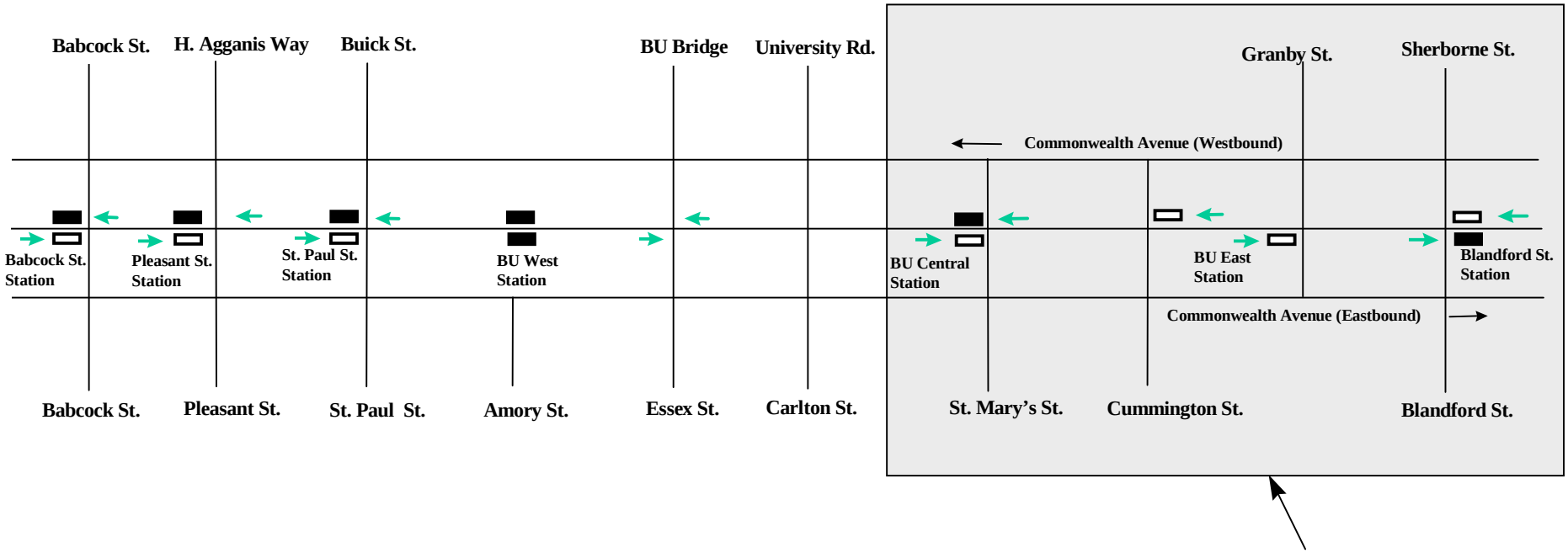
Large percentages of the pedestrians crossing Commonwealth Avenue are passengers boarding or alighting from the Green Line. The MBTA station platforms should be redesigned to better accommodate pedestrian/passenger demand, while providing a safety barrier to protect the people from through traffic on Commonwealth Avenue. The Commonwealth Avenue Road Reconstruction Project (Segment A) recommends widening the MBTA reservations to protect Green Line passengers. This study supports that recommendation.

Passenger Crowding and Service Frequency

We recommend that the MBTA increase the capacity of the Green Line B Branch during the peak period. Possible strategies to explore include the following:

FIGURE 5-4

Green Line B Branch Trolley Priority System, Relocation of Near-Side Stops



Existing far-side intersections that would facilitate trolley priority system.

Existing near-side stations that may not facilitate the operation of a trolley priority system. Relocation to far side of intersection would be recommended where possible and practical.

Intersections where full trolley priority can be provided without an excessive adverse effect on side street automobile traffic during the a.m. and p.m. peak hours.

1. Adding more two-car trains.

2. Examining the issues that would need to be resolved in order to operate three-car trains.

These strategies would increase the number of scheduled seats in the span of service and reduce passenger crowding. Implementing the three-car-train strategy would necessitate longer platforms, particularly if passengers were to use all doors. Other issues that would have to be resolved regarding this strategy are: infrastructure issues -- sufficient power supply, for example; operational issues -- higher probability for equipment malfunction, for example; and human resource issues.

5.4 PEDESTRIAN/BICYCLE ISSUES

Two locations along Route 20 (Commonwealth Avenue) in Boston identified with pedestrian crossing problems are Kenmore Square and the Boston University area. Detailed descriptions of the existing problems are presented in Chapter 2 of this report.

5.4.1 Addressing the Kenmore Square Pedestrian Issues

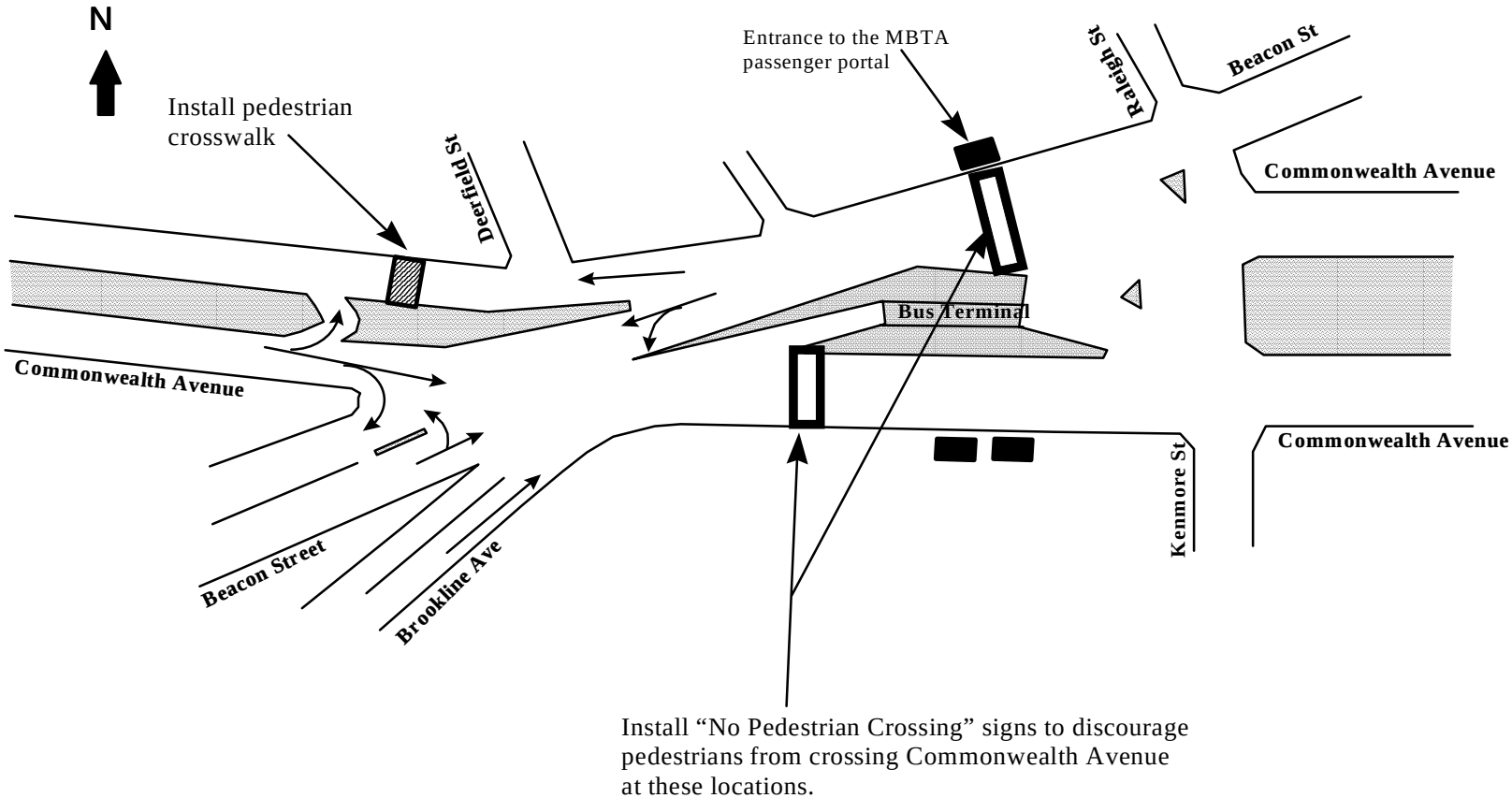
At Kenmore Square, many pedestrians access the MBTA station using the crosswalks (i.e., surface streets). Some cross outside designated crosswalks and in conflict with vehicular traffic. The MBTA portals provide an underground passage to both the surface bus terminal and the Green Line subway station. Within the Kenmore Square area in general, adequate crosswalks have been provided to facilitate crossing. Most of the crosswalks have pedestrian-actuated push buttons and exclusive pedestrian phases.

However, a high volume of pedestrians cross Commonwealth Avenue just west of Deerfield Street, where there is no formalized crosswalk. We recommend that a pedestrian crosswalk be installed at this location to formalize pedestrian crossing (see Figure 5-5). Because this is a non-intersection pedestrian crossing, crosswalk markings (white lines at 45^{o} or 90^{o} to the crosswalk) should be provided for added visibility. Warning signs reading “STATE LAW YIELD TO PEDESTRIANS IN CROSSWALKS” should be installed to warn motorists, and adequate visibility should be provided via parking prohibitions.

A considerable number of pedestrians also cross Commonwealth Avenue at the vehicular entrance and exit of the MBTA bus terminal. These areas, shown in Figure 5-5, do not have formalized crosswalks and are considered hazardous. We recommend the installation of “NO PEDESTRIAN CROSSING” signs to prohibit pedestrians from crossing at these two locations. Further, additional signs should be installed at these locations telling pedestrians to use the portals to access the station. It is expected that installing these signs would divert most of the pedestrians to the portals, which provide easy access. The Kenmore Square study should consider these recommendations to improve pedestrian access and traffic operations and safety.

FIGURE 5-5

Pedestrian Recommendations at Kenmore Square in Boston



5.4.2 Addressing Pedestrian Crossing Problems Along Commonwealth Avenue in the BU Area

Boston University's student-related activities generate high pedestrian volumes along Commonwealth Avenue between Sherborn Street and Babcock Street. Because the B Branch of the Green Line runs in the median of Commonwealth Avenue, passengers always have to cross the streets to board trains or exit from the stations. The high traffic and pedestrian volumes as well as the three traffic lanes westbound on Commonwealth Avenue make pedestrian crossing difficult. The main pedestrian problems along Commonwealth Avenue and its cross-streets are: (1) jaywalking (crossing outside designated crosswalks), (2) pedestrians crossing when the pedestrian light is red or against oncoming traffic, and (3) drivers speeding and failing to yield to pedestrians in crosswalks.

The proposed Commonwealth Avenue Road Reconstruction Project (Segment A) includes several improvements to facilitate pedestrian crossing in the BU area. Widening the existing MBTA reservation, as proposed within the Segment A project limits, would provide both refuge for pedestrians and better protection for them from traffic on Commonwealth Avenue. We recommend that both the City and the MBTA implement this strategy to make it easier for MBTA patrons and pedestrians to cross Commonwealth Avenue. Under this proposal, the existing intra-track fencing will be preserved but the Jersey barriers along Commonwealth Avenue will be removed. Presently, the barriers are placed to protect passengers and other pedestrians from the traffic on Commonwealth Avenue; however, it appears that widening the MBTA reservation would provide enough protection in itself.

The proposed Commonwealth Avenue Road Reconstruction Project (Segment A) also results in shorter crosswalk distances from the reduction in the roadway cross-section. The westbound travel lanes are reduced from three lanes to two to facilitate pedestrian crossing. The design also recommends chokes at the intersections and MBTA platforms to provide more visibility for both motorists and pedestrians and to reduce the crossing distance. In addition, improved pedestrian signal equipment and indications (signals and pushbuttons), approved handicapped facilities, and improved signal phasing that facilitates response to pedestrian actuated calls are proposed as part of this project. It is expected that these improvements would improve pedestrian crossing along Commonwealth Avenue in the BU area significantly.

A one-way bike lane has been recommended for most of the project limits. This bike lane would extend from Babcock Street to Blandford Street on both sides of Commonwealth Avenue and would increase the safety of bicyclists, many of whom are BU students.

6. SUMMARY OF RECOMMENDATIONS, WITH IMPLEMENTATION PLAN

This chapter summarizes our recommendations and provides an implementation plan for carrying them out. Detailed descriptions of our recommended improvements are presented in Chapters 3, 4, and 5 for the portions of Route 20 in Waltham, Watertown, and Boston, respectively.

The following three sections briefly summarize the improvements proposed for the Route 20 corridor by municipality. It should be noted that in these sections they are presented as site-specific improvements and have not been packaged into specific projects. The fourth and final section addresses the implementation plan and process. The implementation plan, in which the recommended improvements are grouped into projects to facilitate carrying them out, is then presented in Table 6-1, which serves also as a summary of the proposed projects.

6.1 RECOMMENDED IMPROVEMENTS IN WALTHAM

- ***Weston Street @ Livingstone Lane/Sibley Road:*** We recommend that a left-turn-prohibition sign, "NO LEFT TURN" (R3-1) be installed at the approaches of Livingstone Lane and Sibley Road. If this suggestion is too restrictive, left-turn prohibition could be limited to the peak periods: 7:00-9:00 a.m. and 4:00-6:00 p.m., Monday through Friday.

  To make it easier to turn right from Weston Street westbound onto Livingstone Lane, we suggest that the approach of Livingstone Lane be widened by a small amount sufficient to provide room at the approach to accommodate two vehicles, one waiting at Livingstone Lane and the other turning right from Weston Street onto Livingstone Lane. If this were done, traffic on Weston Street would not have to slow to a crawl to make a right turn onto Livingstone Lane when there is a vehicle waiting to exit that approach.

  Relocation of the speed limit and obscure road signs on Weston Street westbound between Tavern Road and Livingstone Lane is also recommended. They should be in the direction of the intersection of Weston Street and Cedarwood Avenue/Tavern Road so that motorists will have more time for slowing down to turn right onto Livingstone Lane.

- ***Route 20 Rotary Interchange at Route 128:*** A larger pictographic "KEEP RIGHT" (R4-7) sign should be post-mounted at least four feet above the ground in the gore/median for motorists heading westbound on Weston Street to Route 128 to warn them against entering the wrong way. Combining this sign with the existing "KEEP RIGHT" (R4-7b) sign would produce a complementary effect.

Reduce the speed limit at the Route 20/Route 128 rotary interchange from the current 35 mph to 30 mph. In addition, a combination of a yield sign and a flashing yellow signal should be installed at the ramp entrances to Route 20 to warn motorists and draw their attention to the need to yield before entry.

- ***Weston Street @ Cedarwood Avenue/Tavern Road:*** The circular green lights should be replaced with straight-through green arrows, and the existing no-left-turn sign retained to make it clearer to motorists that they are prohibited from making a left turn from the westbound approach on Weston Street onto Cedarwood Avenue. **(MassHighway has already implemented this change).** We also recommend that this traffic signal be retimed to reduce traffic delays at this intersection.

- ***Main Street @ Weston Street/South Street:*** We recommend that a protected phase be provided for the westbound left turn from Main Street, to eliminate conflict and entrapment. During off-peak periods, this will not have any adverse impact on traffic operations. However, during peak periods, the protected phase may worsen traffic conditions in general and also affect signal coordination along Main Street and Weston Street. Because the safety at this intersection is good, we recommend that, if the protected phase worsens traffic conditions in general during peak periods, the protected-permitted phase plan be restored for the peak periods.

- ***Signal Coordination from Eddy Street to Linden Street:*** We recommend that all the traffic signals on Route 20, from Weston Street @ Eddy Street to Main Street @ Linden Street be retimed and coordinated so that vehicles on Weston Street and Main Street are systematically moved through a sequence of green lights.

- ***Main Street @ Elm Street:*** Main Street eastbound approach, overhead lane-use-control signs (R3-6) should be installed directly over the lanes to which they apply, adjacent to the signal faces, to direct motorists into the appropriate lanes for turning.

  Furthermore, mandatory movement sign "RIGHT LANE MUST TURN RIGHT" (R3-7) should be post-mounted at this approach. We also suggest adding more lane-use-arrow pavement markings at this approach to make the lane shift less confusing.

  At both Main Street approaches, the current three-lense signal face should be replaced with a five-lense cluster signal face to communicate effectively the protected-permissive phasing and move traffic more efficiently. This is particularly important for the shared straight-through-and-left-turn lanes.

- ***Main Street @ Lyman Street/Heard Street:*** We recommend that a traffic signal be installed at this intersection to reduce traffic delay to motorists on Lyman Street and Heard Street. We also propose a shared straight-through-and-left-turn lane at the Main Street eastbound approach to improve traffic operations.

- ***Main Street @ Linden Street:*** Separate signals should be installed for the straight-through traffic and the left-turn traffic at the Main Street eastbound approach. Presently, when the straight-through green arrow comes on for the Main Street eastbound traffic, there is a also circular red indication at the top, and some motorists do not know whether to proceed or to stop. In addition, an auxiliary left-turn sign, "LEFT TURN SIGNAL" (R10-10), should be post-mounted on the left-turn-signal pole to which it applies for clarity and to reinforce compliance with the left-turn signal.

- ***Main Street @ Warren Street/Gore Street:*** The clearance time (yellow plus all-red time) in both directions on Main Street should be increased to 7 seconds to allow bicycles passing through this intersection to cross safely.

- ***Park & Ride Lot at Waltham Central Square:*** About 45-75 more spaces are needed near the Waltham Central Square station to handle commuter rail riders who park at the MBTA lot on Moody Street and at the Carter Street lot. The City of Waltham will be increasing the capacity of the Embassy Lot from 180 to 300 spaces, and this will take care of the problem.

- ***Bicycle Issues:*** Because of the high volumes of traffic, the presence of on-street parking, and the high pedestrian/bicycle accident rate on Route 20, we recommend that bike signs be installed along Route 20 in Waltham to increase motorists' awareness of bicycles and of the need to share the road with them.

  We recommend that bicycle storage facilities be installed at the MBTA lot on Moody Street and Carter Street lot to encourage commuters to bicycle to the "T".

  A feasibility study should be performed on whether a bike lane can be accommodated on the less traveled streets parallel to Route 20 in Waltham -- e.g., Grove, River, and Waltham streets -- providing a continuous bike lane connecting Waltham and Watertown.

6.2 RECOMMENDED IMPROVEMENTS IN WATERTOWN

- ***Main Street @ Lexington Street:*** We recommend that both approaches of Main Street be restriped to accommodate left-turn storage bays and that the traffic signal retimed to improve traffic flow at this intersection. We also recommend upgrading the traffic signal controller.

- ***Main Street @ Myrtle Street/Waverly Avenue:*** We propose that a left-turn storage bay be added to the Main Street eastbound approach and that the traffic signal be retimed to improve traffic flow. We also recommend upgrading the traffic signal controller and interconnecting this signal with the Lexington Street signal to provide coordination.

- ***Watertown Square:*** We recommend that the Watertown Square traffic signal be interconnected and coordinated with the surrounding traffic signals and that the group of signals be revamped to move traffic efficiently and safely through the Square. We also recommend upgrading the signal control equipment to provide an integrated system, whereby

all these signals would be controlled from a single computer (closed-loop system). This would allow effective monitoring and updating of signal timing information and reduce congestion at the Square.

- ***Bus Transit Service:*** A higher frequency of service for Routes 57 and 70/70A is recommended. In addition, the entire paths of Routes 57 and 70 should be studied comprehensively for the purpose of reducing bunching of vehicles.

- ***Bicycle Issues:*** Because of the high volumes of traffic, the presence of on-street parking, and the pedestrian/bicycle accident rate on Route 20, we suggest that bike signs be installed along Route 20 in Watertown to increase motorists' awareness of bicycles and of the need to share the road with them

  We recommend providing bicycle storage facilities at the new MBTA park-and-ride lot to encourage commuters to access transit via bicycle.

A feasibility study should be performed on whether a bike lane can be accommodated on the less traveled streets parallel to Route 20 in Watertown -- e.g., Pleasant, and Waltham streets -- providing a continuous bike lane connecting Waltham and Watertown.

- ***North Beacon Street @ Greenough Boulevard:*** To facilitate the crossing of North Beacon Street by pedestrians and bicyclists, we recommend that a narrow median (about 4 feet wide) be extended from the intersection of North Beacon Street and Nonantum Road to this intersection. Pedestrians and bicyclists would not have to cross all four lanes on North Beacon Street at once, but could cross one-half of the street, wait in the median, and when presented with a sufficient gap cross the remaining half.

We also recommend that pedestrian/bicycle crossing signs be installed at this intersection to warn motorists to yield at the crosswalks. The crosswalks should be striped with white longitudinal lines to provide added visibility for both motorists and pedestrians.

- ***North Beacon Street @ Nonantum Road/Soldiers Field Road/Birmingham Parkway/Parson Street:*** A number of traffic signal improvements are proposed at these intersections to enable vehicles to move more efficiently and safely through the set of lights. Among our recommendations are retiming and synchronization of the traffic signals to reduce traffic delays and to eliminate the weaving and merging of traffic from North Beacon Street and Nonantum Road eastbound.

6.3 RECOMMENDED IMPROVEMENTS IN BOSTON

- ***Commonwealth Avenue from Arlington Street to Massachusetts Avenue:*** We recommend enhancing enforcement to reduce double-parking by maintenance and delivery people. Areas should be created to accommodate the high rate of these services, e.g., delivery in alleys.

- ***Commonwealth Avenue @ Charlesgate East:*** Retiming the traffic signal at this intersection to improve traffic flow is recommended.

- ***Commonwealth Avenue @ Kenmore Square:*** We recommend that the Commonwealth Avenue/Beacon Street/Brookline Avenue traffic signal be retimed to improve traffic flow. Furthermore, the existing phase plan should be modified slightly to provide a lagging protected phase of about 8 seconds for Brookline Avenue traffic, to help bus operations.

Pedestrian crossing at the Square should be improved as part of the Kenmore Square Study, more enforcement provided to reduce double-parking, and improved signage to direct motorists to parking lots.

- ***Commonwealth Avenue from Beacon Street to Brighton Avenue:*** We support and recommend implementation of the Commonwealth Avenue Road Reconstruction (Segment A) Project. This project provides long-term solutions to improve operations and safety for vehicular, transit, pedestrian, and bicycle traffic, as well as enhancement of the landscaping and other amenities.

In the short term, we recommend signal retiming and coordination as well as enhanced pedestrian indications to improve safety and traffic operations along this segment of Route 20. Signal retiming and coordination will also improve bus transit operations and the Green Line B Branch trolley operations. We also recommend removing parking meters located close to intersections to improve sight distances and provide a better view of pedestrian crosswalks. In addition, more enforcement should be provided to minimize illegal and double-parking.

- ***Brighton Avenue @ Harvard Street:*** The traffic signal should be retimed at this intersection and the lanes at both approaches on Harvard Street reconfigured to accommodate a left-turn storage bay. The proposed improvements will improve traffic flow and facilitate bus operations; however, this recommendation may require moving the bus stop at the Harvard Street northbound approach further back so that Route 66 buses can easily make the transition into the left-turn bay to turn onto Brighton Avenue.

- ***North Beacon Street @ Everett Street:*** It is recommended that this signal be connected to the Boston Transportation Department computerized system to improve traffic flow both at this intersection and at the North Beacon Street/Cambridge Street/Brighton Avenue intersection.

In addition, we recommend enforcing the parking prohibition on North Beacon Street westbound between Cambridge Street and Everett Street to improve traffic operations at the North Beacon Street/Cambridge Street/Brighton Avenue intersection.

- ***North Beacon Street @ Market Street:*** At this intersection, our recommendations include left-turn storage bays at both approaches on North Beacon Street. In addition, the traffic signal should be retimed to allocate green time proportionally, and the signal controller equipment should be upgraded. The current post-mounted traffic signals should be replaced with overhead traffic signals, as they do not obstruct sight lines and can be seen from further

away. **(The City of Boston has recently replaced the existing post-mounted traffic signals with overhead traffic signals.)** The existing roadway at this intersection is sufficient to accommodate these improvements.

- ***Green Line B Branch Trolley Operations:*** We recommend providing a trolley signal priority system for the B Branch of the Green Line within the Route 20 corridor to reduce transit delay.

  Full priority can be provided to trolleys at the intersections east of University Road/Carlton Street during peak periods without excessive adverse impact on the side street traffic delays. These are the intersections of Commonwealth Avenue with Blandford Street/Sherborn Street, Granby Street, Cummington Street, and St. Mary's Street.

  During the peak periods, providing a full priority can have excessive adverse effect on the side streets for the following intersections of Commonwealth Avenue: University Road/Carlton Street, BU Bridge/Essex Street, Buick Street/St. Paul Street, H. Agganis Way/Pleasant Street, and Babcock Street. These intersections have higher traffic volumes and a full trolley signal priority would result in poor levels of service for the side streets traffic (LOS E of worse).

  We also recommend, where practical, relocating near-side station platforms to the far side of the intersection to take advantage of the trolley signal priority system.

- ***Bus Transit:*** For Routes 57 and 66, frequency should be increased and measures introduced to prevent bunching of buses. Traffic management strategies proposed for the Route 20 corridor will also help bus transit operations by reducing traffic signal delays.

6.4 IMPLEMENTATION

6.4.1 Implementation Plan

Because there are multiple jurisdictional and administrative structures relevant to implementation of the study's recommendations, the implementation plan, which is presented in Table 6-1 and Figures 6-1 through 6-3, clearly defines the implementation agencies and allows the proposed improvements to be carried out independently or in phases.

Recommended improvements and strategies with common characteristics have been assembled into projects. The table provides a summary of each project and indicate its location, implementing agency, and estimated cost. It should be noted that such recommendations as enforcement of parking prohibitions are not included in the implementation plan. The plan is

TABLE 6-1

Route 20 Transportation Planning Study: Proposed Projects
Summary and Implementation Plan

Project Type	Project Description	Location	Implementing Agency	Estimated Cost
Intersection Improvements for Safety and Traffic Operations	***Improve traffic operations along Main Street & Weston Street in Waltham.*** Coordinate traffic signals, make safety improvements, and perform related work at these intersections*:* 1. Main Street @ Linden Street 2. Main Street @ Newton Street 3. Main Street @ Appleton Street 4. Main Street @ Elm/Church Street 5. Main Street @ Moody/Common Street 6. Main Street @ Lexington Street 7. Main Street @ Exchange Street 8. Main Street @ Bacon Street 9. Main Street @ Prospect/Hammond Street 10. Main Street @ South/Weston Street 11. Weston Street @ Eddy/Cabot/Vernon Street	Waltham	City of Waltham	$250,000
Intersection Safety and Traffic Improvements	***Improve intersection of Main Street & Lyman Street/Heard Street.*** Install traffic signal and reconfigure lane assignment at this intersection.	Waltham	City of Waltham	$100,000
Intersection Traffic Improvements	***Improve traffic operations at the intersection of Weston Street & Cedarwood Avenue/Tavern Road.*** Update traffic signal timings.	Waltham	MassHighway-District 4	$20,000
Intersection Safety and Traffic Improvements	***Make safety improvements at the intersection of Weston Street & Livingstone Lane/Sibley Road and at the Route 20 rotary interchange at Route 128 in Waltham.*** Upgrade signage and make other safety improvements at the intersection of Weston Street and Livingstone Lane/Sibley Road. Widen the approach of Livingstone Lane. Reduce speed limit on the Route 20/Route 128 rotary interchange to 30 mph and upgrade signage at the westbound entrance east of Route 128.	Waltham	MassHighway-District 4	$60,000

TABLE 6-1 (Cont.)

Route 20 Transportation Planning Study: Proposed Projects
Summary and Implementation Plan

Project Type	Project Description	Location	Implementing Agency	Estimated Cost
Bicycle Safety Improvements	***Improve signage along Route 20 for motorist accommodation of bicycle traffic.*** Install signs directing motorists to watch out for bicyclists and to share the road with them.	Waltham and Watertown	City of Waltham and Town of Watertown	$50,000
Intersection Safety and Traffic Improvements	***Improve the intersection of Main Street and Lexington Street.*** Retime traffic signal, upgrade signal controller equipment, and make geometric improvements.	Watertown	MassHighway-District 4 The Route 20 Discontinuance Project (in progress) is assessing the impact of transferring this intersection from MassHighway to the Town of Watertown.	$40,000
Intersection Safety and Traffic Improvements	***Make safety improvements at the intersection of North Beacon Street & Greenough Boulevard.*** Construct a narrow median (about 4 ft.) along North Beacon Street to provide pedestrian refuge and allow staged crossing. Install pedestrian and bicycle signs to warn motorists. Provide longitudinal lines in the crosswalks for added visibility to pedestrians, bicyclists, and motorists.	Watertown	Metropolitan District Commission	$50,000
Intersection Safety and Traffic Improvements	***Improve the intersection of Main Street & Waverly Avenue/Myrtle Street.*** Retime traffic signal, update signal controller equipment, and make geometric improvements.	Watertown	Town of Watertown	$50,000
Intersection Safety and Traffic Improvements	***Improve the Watertown Square intersection.*** Retime traffic signal, update signal controller equipment, and provide closed-loop system to interconnect and allow coordination with the following surrounding traffic signals: 1. Galen Street @ Watertown Street 2. Main Street @ Pleasant Street 3. Main Street @ Church Street 4. North Beacon Street @ Arsenal Street	Watertown	Town of Watertown	$150,000

TABLE 6-1 (Cont.)

Route 20 Transportation Planning Study: Proposed Projects
Summary and Implementation Plan

Project Type	Project Description	Location	Implementing Agency	Estimated Cost
Bus Transit Improvements	***Improve schedule adherence and frequency for Route 57, 64, 66, and 70/70A services.***	Boston, Watertown, and Waltham	Massachusetts Bay Transportation Authority	$100,000 per year
Bicycle Storage Facilities	***Provide bicycle storage facilities.*** Install bicycle lockers at bus transfer points and park-and-ride facilities for bicyclists at the following locations: 1. Waltham Central Square Parking Deck 2. MBTA Park-and-ride lot on Moody Street 3. Watertown Square Terminal 4. Watertown Yard Terminal 5. Union Square	Boston, Watertown, and Waltham	Massachusetts Bay Transportation Authority	$50,000
Intersection Safety and Traffic Improvements	***Improve traffic and transit operations and make pedestrian safety improvements along Commonwealth Avenue from Blandford/Sherborn Streets to Babcock Street.*** The City of Boston's Commonwealth Avenue Road Reconstruction Project (Segment A) will address the problems.	Boston	City of Boston	As estimated in the 1997-1999 Transportation Improvement Program (TIP). See Appendix M.
Intersection Safety and Traffic Improvements	***Improve traffic operations and safety at the following five intersections:*** 1. Commonwealth Avenue @ Charlesgate East 2. Kenmore Square 3. Brighton Avenue @ Harvard Street 4. Cambridge Street @ Brighton Avenue/North Beacon Street 5. North Beacon Street @ Market Street	Boston	City of Boston	$50,000
Green Line B Branch Improvements	***Provide signal priority for Green Line B Branch trolleys.*** Install a trolley priority system for the Green Line B Branch. Relocate Green Line B Branch near-side stations to far side of intersections to benefit from trolley priority system on Commonwealth Avenue. (Note: This project should be implemented along with the Commonwealth Avenue Road Reconstruction Project (Segment A). The Commonwealth Avenue Road Reconstruction Project (Segment A) include provision of trolley priority system. However, relocation of the Green Line station platforms is not included in the Commonwealth Avenue reconstruction project.	Boston	Massachusetts Bay Transportation Authority/City of Boston	It is estimated to cost $50,000 to relocate a near-side station.

intended not only to provide flexible choices for decision makers, but also to simplify such issues as funding.

6.4.2 Implementation Process

Highway Projects

The Massachusetts Highway Department's Bureau of Transportation Planning and Development will assist the municipalities with the implementation of projects derived from this study. The process for Waltham, Watertown, or Boston to implement a highway project located along Route 20 is as follows:

1. The municipality must request in writing assistance from the Massachusetts Highway Department (MassHighway) District Four Director. The letter should explain why the proposed improvements are needed, describe the improvements, indicate the level of local support for the project, and include a commitment that the project will be designed by the municipality and that any ROW acquisitions or easements required will be the responsibility of the municipality. A copy of the letter should be sent to the Executive Secretary of the Boston Metropolitan Planning Organization (MPO) as well.

2. The District office will review the request and may request a Project Justification Report. It is the responsibility of the municipality to prepare the report, if requested, and submit it to the District office and the MPO.

3. At this point, the municipality should meet with the District office and MPO to discuss the potential priority of the proposed project and plan the remaining steps to complete the process, including an informational meeting at which the degree of community support or opposition will be determined.

4. If District Four's evaluation of the project is favorable and there is local support for the project, the District will submit a favorable request to the Project Review Committee (PRC) of MassHighway. The PRC then approves or disapproves the proposed project and MassHighway notifies the municipality of the result.

5. Once the proposed project is approved, the municipality can request that the MPO place the project in the Transportation Improvement Program (TIP). The project must carry with it regional benefits and comply with the Regional Transportation Plan.

6. Once the project is in the TIP, the municipality can prepare the necessary construction documents. Depending on the complexity of the project, submittals may be required at the 25%, 75%, or 100% design phase.

7. MassHighway advertises and awards the project, and issues a notice to proceed, whereupon construction may begin.[20]

Funding for projects along the Route 20 corridor can come from a variety of funding categories. It should be noted that many projects compete for the same money; therefore, the priority of the project will determine if it is assigned to a funding category and placed in the TIP. The eligible funding categories for Route 20 projects are as follows:

- **National Highway System (NHS) -** Funding for projects on all National Highway System roadways.

- **Non-Federal Aid (NFA)** - Funding for construction, reconstruction, and improvement projects on roads and bridges in urban and rural areas.

- **Surface Transportation Program (STP)** - Funding for projects chosen by states and localities on any roads that are not functionally classified as local or rural minor collectors.

- **STP Earmark (STP O)** - A portion of the STP funding earmarked for urban areas with a population over 200,000 (still must be for projects chosen by states and localities on roads that are not functionally classified as local or rural minor collectors).

Transit Projects

The MBTA's Service Delivery Policy provides a consistent procedure for the provision of MBTA transit services throughout its service area, including the implementation of service changes. All service changes are subject to a review and approval process to ensure that they are consistent with the service guidelines and MBTA Board initiatives, and that they can be implemented within the adopted budget. The process to implement a transit project (service change or new service proposal) is as follows:

1. Requests for service changes and new service proposals can be made by anyone – private citizens, elected officials, MBTA employees, representatives of neighborhood groups, business organizations, etc. Upon receipt, a request for service changes will be reviewed by the Manager of Service Planning. If the request appears to be consistent with the MBTA's policies, it will be assigned to a service planner for analysis. If the request is not consistent with MBTA service guidelines or policies, the Planning Department will inform the party making the request, in writing, of why the request is being denied.

2. All analysis of service requests will be done by the Service Planning unit of the Planning Department. This analysis will be based on the factors described in the "Evaluation Criteria" section of the Service Delivery Policy. In conducting the analysis, Service

[20] The above process assumes that none of the recommendations requires environmental impact assessments.

Planning will coordinate with other MBTA departments that would be involved in the proposed change, as well as the proponent of the service change.

3. Following evaluation of the service request and review by the Service Planning Committee, Service Planning will recommend that either (1) the request be implemented, (2) a variation of the request be implemented, (3) the change be deferred, or (4) the request be denied. Summary of the analysis and recommendations will be forwarded to the party making the original request. The decision to implement the change and the timing of the change will depend on the significance of the change and whether or not capital expenditures are required.

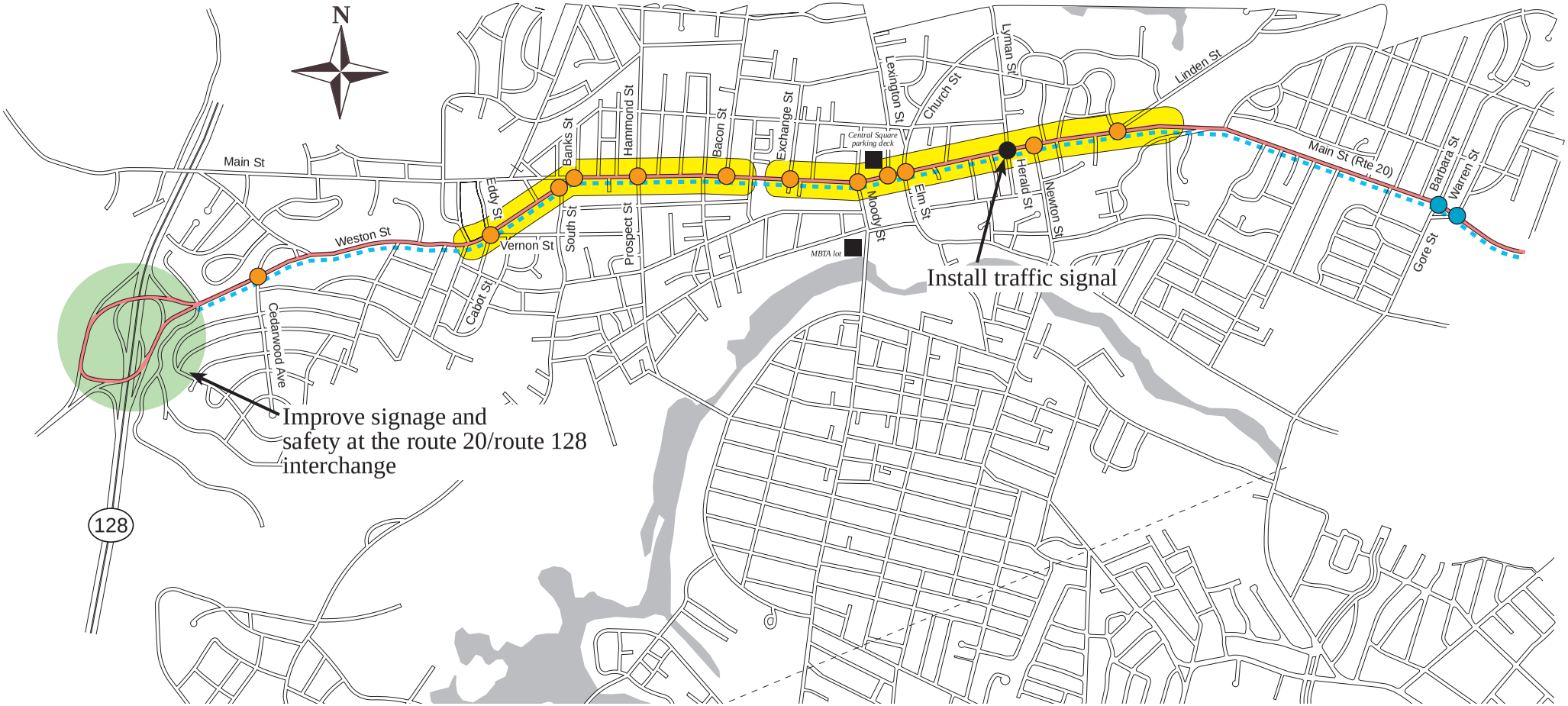
4. In general, minor changes that can be met in the adopted budget will be implemented as quickly as possible. Minor changes that would increase costs will be held until they can be "bundled" with other changes that would reduce operating costs by an equal amount. Minor changes are implemented based upon the final recommendation of the Service Planning unit of the Planning Department.

5. The implementation of moderate changes will be handled similar to that of minor changes. If the change does not involve an increase in operating costs, it will be implemented as quickly as possible. Moderate changes that would increase costs will be held until they can be "bundled" with other changes that involve offsetting operating cost reductions. Moderate changes must be approved by the Executive Service Oversight Committee.

6. Major changes will be evaluated within the context of a "comparative evaluation" and the development of the Annual Service Plan. The comparative evaluation will weigh all of the potential major changes received and evaluated throughout the year and determine which would represent the best allocation of resources. Major changes must be endorsed by the Executive Service Oversight Committee and receive the approval of the General Manager or the MBTA Board of Directors. In most cases, the MBTA Board's approval will be via approval of the Annual Service Plan. If the change is determined to be among the most effective major changes that can be implemented within the coming year's budget, it will be recommended in the Annual Service Plan.

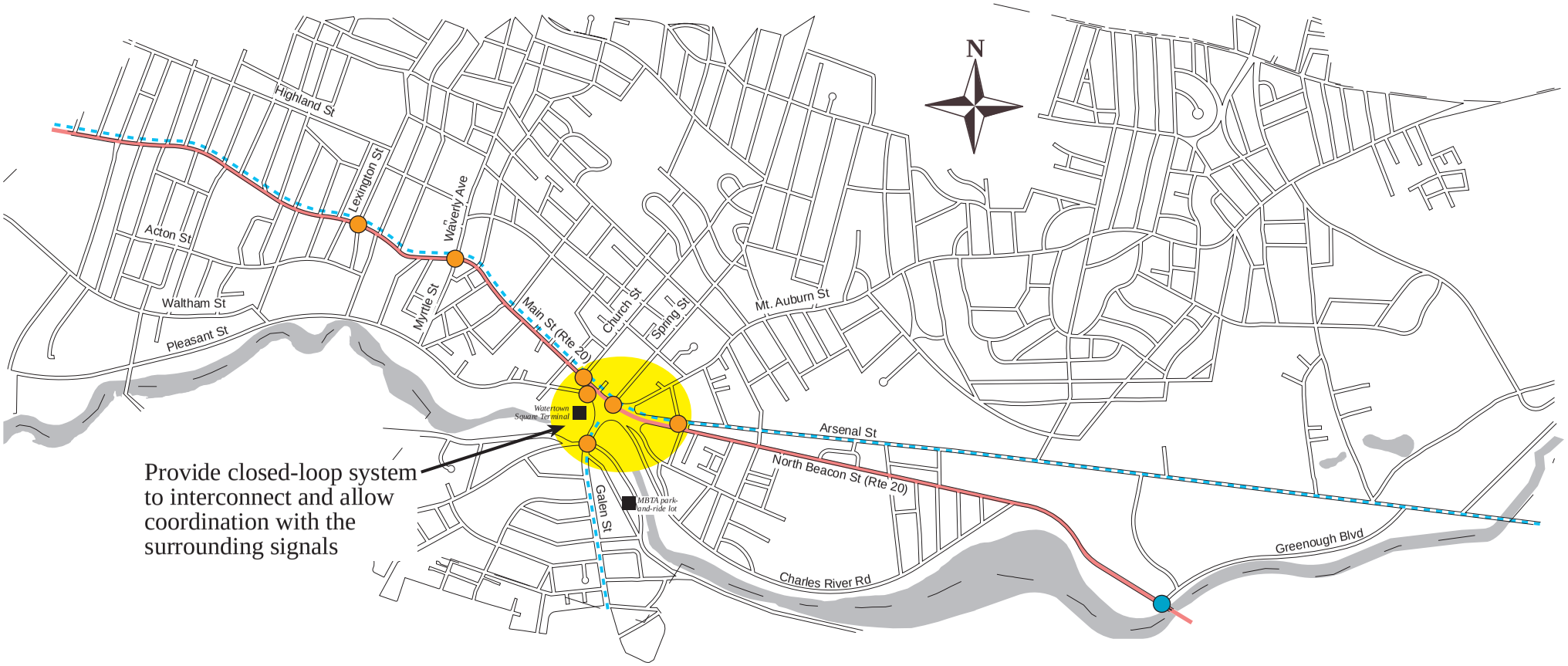
7. The MBTA is currently reviewing this policy and will make modifications as appropriate. Any changes requiring capital expenditure or changing the type of amenities available at transit facilities are subject to study.

FIGURE 6-1
Summary of Proposed Improvements in Waltham



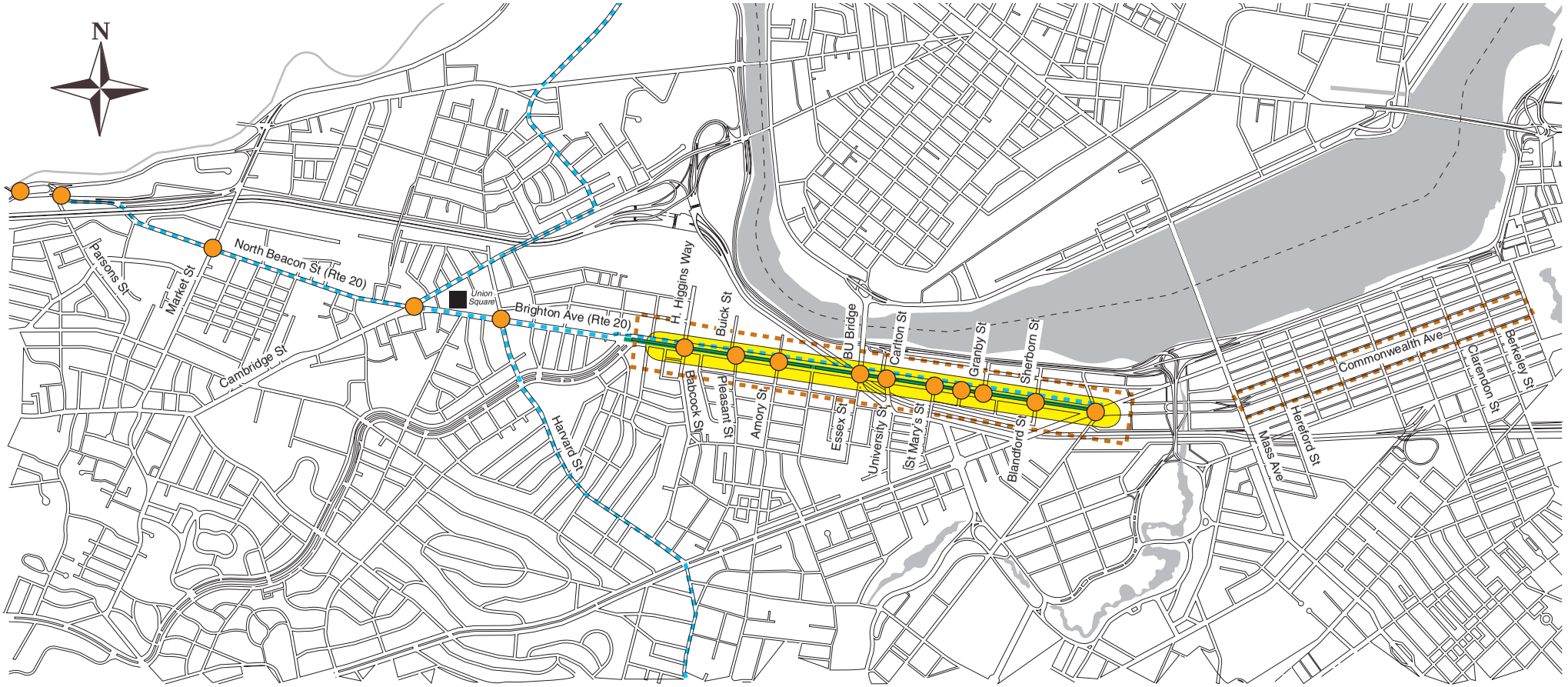
- Retime traffic signal, update signal controller equipment, and make geometric improvements
- Coordinate signals to provide progression
- Improve signage along Route 20 for motorist accommodation of bicycle traffic
- Make safety improvements at intersection to facilitate crossing by pedestrians and bicyclists
- Install bicycle storage facilities (at bus terminals and park-and-ride lots)
- Improve frequency and schedule adherence for bus route 70/70A

FIGURE 6-2
Summary of Proposed Improvements in Watertown



- Retime traffic signal, update signal controller equipment, and make geometric improvements
- Improve signage along Route 20 for motorist accommodation of bicycle traffic
- Make safety improvements at intersection to facilitate crossing by pedestrians and bicyclists
- Install bicycle storage facilities (at bus terminals and park-and-ride lots)
- Improve frequency and schedule adherence for bus routes 70/70A and 57

FIGURE 6-3
Summary of Proposed Improvements in Boston



Introduce measures to reduce double-parking and illegal parking

Retime traffic signal, update signal controller equipment, and make geometric improvements

Coordinate signals to provide progression

Install signal priority system for the Green Line B Branch trolleys

Install bicycle storage facilities (at bus terminals and park-and-ride lots)

Improve frequency and schedule adherence for bus routes 66 and 57